gives the trend for the capacity requirement, actual limit capacity, required peak load capacity and the supply balance.

It can be seen that the power balance will be positive from 1996 onward but become negative in 1998. Consequently, it will be absolutely vital to commission a new diesel unit in 1999 if the connection of the Manantali hydroelectric power station to the grid should fall behind schedule.

While the power balance offers no margin for 1994 and 1995 if we assume that the time availability of the plant is 70% (for 6,132 hours), the generating facility does give confidence that the necessary reserve capacity will be available to permit appropriate plant maintenance in the operating schedule with effect from 1996.

6.4 Selection of the Installation Location for the Power Generating Facilities

As an urgent priority of the development of electric power system, it is necessary to select the actual installation location for generating facilities depending on the foregoing examination.

The investigation for the feasibility study was carried out mostly on the Bel-Air Power Station. As an alternative location, however, the study also took into consideration the Cap des Biches Power Station.

The major issues are the suitability and the optimum siting of the building which is to house the generating facilities and the bus bar for connecting the generators. Basic planning of generating facilities in the both stations are as follows.

<u>Bel-Air Power Station</u>

* The new facilities shall be aligned in the building with existing 5,000 kW diesel units in the power station and their output shall be connected to the 6.6 kV busbar in the same manner as the existing diesel generators.

* The new facilities shall be aligned in the building with the existing 5,000 kW diesel units in the power station and shall be connected to the 30 kV busbar through a step-up transformer.

* The space near the outdoor 90 kV switchyard shall be utilized to build a new building for the generating facility and the facility shall be connected to the 90 kV busbar via step-up transformer.

Fig. 3.1-1 is a plan view of the building with the existing diesel generating facilities and its surroundings.

Cap des Biches Power Station

* The space next to the building with the existing 20,000 kW diesel generators is intended for future extension programs and is already prepared for construction. This space might be ideal for the new facilities with connection to the 30 kV busbar in the indoor distribution switchgear station. As stated in 6.3.2 (1), however, the foundation work for the installation of the future diesel units in 1997 and 1999 has already been completed so as to be aligned with the existing building. Consideration has also been given to the laying of power cable to 90 kV switchgear station without intersection and utilization of the space next to the existing outdoor switchgear station.

  Therefore the new arrangement of diesel generating facilities will be as shown in 6.4-1 and it will need construction of new building to house them and expansion of existing indoor switchgear for the connection to 30 kV busbar.

(1) Bel-Air Power Station

In case of the Bel-Air Power Station provided with additional 10,000 kW, it would mean that a further 10,000 kW would be added to the existing circuit of the two 5,000 kW units installed in 1991 under the grant aid by the Japanese Government. Totally 20,000 kW implies a roughly 40% addition to the existing four 12,500 kW generating units, totaling capacity of 51,200 kW, and following items should be examined for confirmation of possibilities for the additional generating capacity. Fig. 6.4-2 is a single line diagram of the power station.

1) Main issues for load dispatching
2) Busbar arrangement
3) Aging of facilities
4) Short-circuit current and interrupting capacity
5) Space for extension
6) Environmental impact

1) Main issues for load dispatching

At present, the Bel-Air Power Station's generating facilities consist of the rather obsolete heavy oil fired thermal power generating units which has been kept in operation well beyond its normal service life and the diesel generator units installed under the grant aid by the Japanese Government. The relation between the generating facilities and the transformer installations are as follows.

a. Capacity of generating facility

Steam generating facilities	12,500 kVA x 4 =	50,000 kVA
Diesel generating facilities	6,250 kVA x 2 =	12,500 kVA
Total		62,500 kVA (1)

b. Transformer capacity

6.6/90 kV units	10,000 kVA x 3 =	30,000 kVA
6.6/30 kV units	7,975 kVA x 2 =	15,950 kVA
6.6/6.6 kV units	20,000 kVA x 2 =	40,000 kVA
Total		85,950 kVA (2)

The spare capacity ratio is thus (1)/(2) = 0.73. Normally, this ratio is around 0.7 and they are reasonably in balance. Further increase of the generating facilities, special consideration of system operation will be needed.

If it will not be possible to retire for the old steam generating facilities on schedule, the need might possibly arise for some power absorption capacity to be installed temporarily. It is definitely not desirable therefore to connect any further generators directly to the existing 6.6 kV busbar since this would give rise to restrictions in system operation.

The proposal that the generating facilities should be connected to the 30 kV busbar might increase supply capability of 30 kV circuit, substitute 30 kV feeders from Hann Substation and be one of the means of resolving the above problems concerning the 6.6 kV busbar configuration.

The proposal suggesting that the generating facilities should be connected to the 90 kV busbar would only be a practical plan for the supply through the 90 kV transmission line into the Hann and Cap des Biches directions. In the long term, however, the supply will be for the 6.6 kV and 30 kV systems since the energy generated will be consumed in the vicinity of Bel-Air. The 30 kV busbar can therefore be regarded as most suitable.

2) Busbar arrangement

As shown in Fig. 6.4-2, the existing busbar consists of a double busbar arrangement. The policy is that when one of the busbars fails the other busbar is available so that operation can be maintained without disruption.

The indoor type switchgear for the existing steam generating units and the diesel generator building are connected by underground power cable. The rated current for the series-connected equipment in this linkage circuits (circuit breakers and disconnecting switches) are specified as 2,000A. The rated current of the two 5,000 kW (total 10,000 kW, 12,500 kVA) diesel generator block is 1,094A. If this current is to be fed to the 6.6 kV busbar in the same manner as with the existing equipment, the total current would be 2,187 A and therefore in excess of the

2,000 A current rating for the series-connected equipment in the linkage circuit. Even deducting the power consumed for station service, it can be realized that it will not be possible to maintain single busbar operation if all the generators are operational. It is therefore not possible to use the same method of installation as that used previously for the existing diesel generating units. Another possibility worth considering is the fixing of two units to each of the busbars. The problem with this method, however, would be that it would upset the design philosophy and this would not be recommended.

In this connection, the problems could be overcome by connecting the new generator units to the 30 kV busbar via 6.6/30 kV step-up transformers. This arrangement would meet the current rating even with a double busbar arrangement.

If the generator block is connected to the 90 kV busbar, the problem would be that any busbar failure would inevitably lead to the shutdown of the generating facility because of a single busbar configuration.

3) Aging of facilities

At the Bel-Air Power Station, deterioration of the facilities due to aging is remarkable and those parts in which aging are not seen obviously are particularly serious. The supporting insulators for the busbar conductors, the insulation strength of the underground cables, the corrosion of the buried cable conduits, the contactors of the disconnecting switch and the interrupting capacity of the circuit breakers are examples in point. It is not, however, recommendable to replace these elements partially because of considerable difficulties of replacement and danger.

4) Short circuit current and interrupting capacity

The short circuit current in the busbars can only be estimated roughly as there are no details on the reactance values for the existing power generators. It is clear, however, that the direct connection of all generator units to the 6.6 kV busbar would suggest a rather large short circuit current. If, furthermore, the fault current flowing from the 90 kV system is taken into consideration, there would be problems even with the present circuit breakers and interrupting capacity. Nor would it be possible to connect the new power generators directly to this 6.6 kV busbar.

This might require some further examination, and it might conceivably be necessary to adopt some suitable measure to reduce the short circuit current by, for example, operating the busbars separately.

In this connection, the connection of the new generators to the 30 kV busbar would be a worthwhile as a means of controlling short circuit current increase in the 6.6 kV busbar.

5) Space for extension

The two new 5,000 kW diesel generators to be installed under this project can be erected in the building which already accommodates the existing diesel generator facilities. And, indeed,it is desirable to install similar types of facilities in the same place.

In the event that the new generating facilities should be connected directly to the existing 6.6 kV busbar, the same design as that for the existing diesel generator block would be adopted. If the connection is made to the 30 kV busbar, however, a step-up transformer would need to be installed in the old generator building so that the connection to the 30 kV busbar in the switchgear building next to the main building could be made through 30 kV power cables.

The breakers, protection relays and control panels for the new diesel generators should be installed by way of expansion of the control room in the present building, with the possibility of providing a monitoring in the main control room to cover the needs for the 30 kV systems.

6) Environmental impact

In view of the geographic location of Bel-Air, it needs at least to maintain present noise level which affect directly to the citizens at the new installation of 2 units of diesel generator set in addition to the existing 4 units of steam generating facilities and 2 units of diesel generator.

Others will be discussed in Chapter 12 titled "Environmental Assessment".

(2) Cap des Biches

The installation of further 10,000 kW generating facility at the Cap des Biches power station would be different from that of the Bel-Air power station, as can be soon from the single line diagram of Fig. 6.4-4. The short circuit current in the busbar would not be so great since the generators are connected to the busbars through transformer. The following points should be examined.

1) Connection to existing busbar

Two cases can be considered. One is to connect the generators to the busbar in the existing 30 kV indoor switchgear, and the other to connect the new generators to the outdoor 90 kV busbar. The connection to the 30 kV busbar with certain modification to it would be more advantageous from view points of the cost and the ability to withstand short circuit.

2) Operating method

Operation should be by remote control from the present control room for the existing 20,000 kW diesel generating facility. The operating panel for remote control and monitoring should be installed in the existing control room for unmanned operation.

3) Control range

From the existing diesel generator control room, the operation of generator start/stop and output and voltage control and operation of the switchgear on the 30 kV side shall be the responsibility of the control room (C III) for the steam generating facility.

4) Synchronizing method

For synchronization, independent synchronizers shall be installed on the diesel generator side.

5) Short circuit current

Since this is a relatively new facility with new design and has a margin so that it will not present any problem in terms of short circuit currents for a very long time.

6) Existing 30 kV indoor switchgear

Modification of the existing indoor 30 kV switchgear would be required as an extra since there is no spare feeder with the circuit breaker and disconnecting switch in the existing facility.

7) Environmental impact

In view of the environment impact due to the existing diesel generators, the building should be designed by taking noise measures into consideration, and it would not be difficult to maintain noise levels at the present values.

Further environmental aspects will be discussed in Chapter 12 titled "Environmental Assessment".

(3) Selection of Installation Sites for Generating Facilities

In recognition of the above study and on the basis of overall comparison including construction cost, following assessment has been made and in the light of this evaluation the Bel-Air has been selected as the installation site.

Comparison of Installation Site

Item	Bel-Air Power Station	Cap des Biches Power Station
1. Location	Near to the demand centre, favorable from view point of dispersion of power stations	A little remote from centre of Dakar city, centralization of power stations
2. System Operation	Though capacity problem in present facility, favorable from view point of supply reliability, voltage control	Enough capacity in present facility, but problem of voltage control due to concentration of power source
3. Future Expansion	By reinforcing the capacity of facility, it will become reliable power source in the load center	Very important facility for introduction of future hydro-power and no restriction for future expansion
4. Harmony with existing facility	Very good harmony with existing diesel units making a complete power station by 4 generators	New generators will be a little different in capacity and not good balance with existing machines
5. Connection Bus	30 kV Bus	30 kV Bus
6. Cost Increase	Cost for 6.6/30 kV facilities will be increased	Cost for generator housing expansion of switchgear building and 6.6/30 kV facilities
7. Environmental Impact	Located in the city, careful attention should be paid	Now very little housing around the station

Table 6.3.2-1 Power Demand and Supply Balance

Short Term Development

Item	Name type	Capacity	1994	1995	1996	1997	1998	1999	Remarks
Bel-Air (CI)	G105	Rated	5,000	5,000	5,000	5,000	5,000	5,000	
	-	Economical	4,500	4,500	4,500	4,500	4,500	4,500	
	Diesel	Actual limit	5,000	5,000	5,000	5,000	5,000	5,000	
	G105	Rated	5,000	5,000	5,000	5,000	5,000	5,000	
	-	Economical	4,500	4,500	4,500	4,500	4,500	4,500	
	Diesel	Actual limit	5,000	5,000	5,000	5,000	5,000	5,000	
Bel-Air (CII)	G101	Rated	12,800	12,800	12,800				scrap year : 1997
	Steam	Actual limit	5,000	10,000	10,000				
	G102	Rated	12,800	12,800	12,800	12,800	12,800	12,800	scrap year : 2000
	Steam	Actual limit	9,000	10,000	10,000	10,000	10,000	10,000	
	G103	Rated	12,800	12,800	12,800	12,800	12,800	12,800	
	Steam	Actual limit	11,000	10,000	10,000	10,000	10,000	10,000	
	G104	Rated	12,800	12,800	12,800	12,800	12,800	12,800	
	Steam	Actual limit	5,000	10,000	10,000	10,000	10,000	10,000	
Cap des Biches (CIII)	G301	Rated	27,500	27,500	27,500	27,500	27,500	27,500	
	Steam	Actual limit	27,500	27,500	27,500	27,500	27,500	27,500	
	G302	Rated	30,000	30,000	30,000	30,000	30,000	30,000	
	Steam	Actual limit	20,000	20,000	30,000	30,000	30,000	30,000	
	G303	Rated	30,000	30,000	30,000	30,000	30,000	30,000	
	Steam	Actual limit	15,000	30,000	30,000	30,000	30,000	30,000	
	TAG1	Rated	16,500	16,500	16,500	16,500	16,500	16,500	
	-	Economical	15,000	15,000	15,000	15,000	15,000	15,000	
	Gas	Actual limit	15,000	15,000	15,000	15,000	15,000	15,000	
	TAG2	Rated	21,500	21,500	21,500	21,500	21,500	21,500	
	-	Economical	15,000	15,000	15,000	15,000	15,000	15,000	
	Gas	Actual limit	19,000	19,000	19,000	19,000	19,000	19,000	
Cap des Biches (IV)	G401	Rated	20,000	20,000	20,000	20,000	20,000	20,000	
	-	Economical	19,000	19,000	19,000	19,000	19,000	19,000	
	Steam	Actual limit	20,000	20,000	20,000	20,000	20,000	20,000	
	G402	Rated	20,000	20,000	20,000	20,000	20,000	20,000	
	-	Economical	18,000	18,000	18,000	18,000	18,000	18,000	
	Steam	Actual limit	20,000	20,000	20,000	20,000	20,000	20,000	
Saint-Louis	-	Rated	3,250	3,250	3,250	3,250	3,250	3,250	
	-	Economical	2,925	2,925	2,925	2,925	2,925	2,925	
	Diesel	Actual limit	3,250	3,250	3,250	3,250	3,250	3,250	
	-	Rated	3,250	3,250	3,250	3,250	3,250	3,250	
	-	Economical	2,925	2,925	2,925	2,925	2,925	2,925	
	Diesel	Actual limit	3,250	3,250	3,250	3,250	3,250	3,250	
	-	Rated	2,000	2,000	2,000	2,000	2,000	2,000	
	-	Economical	1,800	1,800	1,800	1,800	1,800	1,800	
	Diesel	Actual limit	2,000	2,000	2,000	2,000	2,000	2,000	
	-	Rated	2,000						
	-	Economical	1,800						
	Diesel	Actual limit	2,000						
Kaolack	-	Rated	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Economical	3,150	3,150	3,150	3,150	3,150	3,150	
	Diesel	Actual limit	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Rated	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Economical	3,150	3,150	3,150	3,150	3,150	3,150	
	Diesel	Actual limit	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Rated	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Economical	3,150	3,150	3,150	3,150	3,150	3,150	
	Diesel	Actual limit	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Rated	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Economical	3,150	3,150	3,150	3,150	3,150	3,150	
	Diesel	Actual limit	3,500	3,500	3,500	3,500	3,500	3,500	

Source : Statistical operation record by SENELEC (August 1994)

Table 6.3.2-2 Power Demand and Supply Balance
Short Term Development

Item	Unit	Capacity	1994	1995	1996	1997	1998	1999	Remarks
The existing capacity (RI) : (1) Diesel unit	kW	Rated	60,500	58,500	58,500	72,500	72,500	72,500	
	kW	Economical	55,450	53,650	53,650	66,250	66,250	66,250	
	kW	Actual limit	60,500	58,500	58,500	72,500	72,500	72,500	
Steam turbine	kW	Rated	138,700	138,700	138,700	125,900	125,900	125,900	
	kW	Actual limit	92,500	117,500	127,500	117,500	117,500	117,500	
Gas turbine	kW	Rated	38,000	38,000	38,000	38,000	38,000	38,000	
	kW	Economical	30,000	30,000	30,000	30,000	30,000	30,000	
	kW	Actual limit	34,000	34,000	34,000	34,000	34,000	34,000	
The existing capacity (Kaolack) (2)	kW	Rated	14,000	14,000	14,000				
	kW	Economical	12,600	12,600	12,600	(interconnect to RI)			
	kW	Actual limit	14,000	14,000	14,000				
The existing capacity (RGI) (1)+(2)	kW	Rated	237,200	235,200	235,200	236,400	236,400	236,400	
	kW	Economical	-	-	-	-	-	-	
	kW	Actual limit	187,000	210,000	220,000	224,000	224,000	224,000	
Projected : Cap des Biches (TAG3)	kW	Rated		20,000	20,000	20,000	20,000	20,000	
EXT-CIV	kW	Rated				18,000	18,000	18,000	
EXT-CIV	kW	Rated						18,000	
Diesel SR	kW	Rated				10,000	10,000	10,000	5,000x2unit
Total capacity of RGI (existing + projected) (A)	kW	Rated	237,200	255,200	255,200	284,400	284,400	302,400	
	kW	Actual limit	187,000	230,000	240,000	272,000	272,000	290,000	
Peak load forecasted (B)	kW	-	181,900	187,100	191,000	209,900	216,100	220,800	at generating end
Off-peak load (C)	kW	-	90,950	93,550	95,500	104,950	108,050	110,400	estimated as 50% of peak load
Reserve margine :									
Stoppage of 1st & 2nd largest units	kW	Rated	60,000	60,000	60,000	60,000	60,000	60,000	
ditto (D)	kW	Actual limit	47,500	57,500	60,000	60,000	60,000	60,000	
Balance[(A)-(B)-(D)]	kW	Actual limit	-42,400	-14,600	-11,000	2,100	-4,100	9,200	at generating end
Reserve margine :		-							
20% capacity of peak load (E)	kW	-	36,380	37,420	38,200	41,980	43,220	44,160	at generating end
Balance [(A)-(B)-(E)]	kW	Actual limit	-31,280	5,480	10,800	20,120	12,680	25,040	
Spinning reserve :									
Deviation of load fluctuation (σp)	kW	-	5.4	5.5	5.5	5.8	5.9	5.9	Proportional constant of σp=0.4
Regulating capacity (≦1Hz) (F)	Hz	-	19,579	19,886	20,112	21,181	21,521	21,775	Power constant : 1%MW/0.1Hz
Difference : corresponding unit (G)	kW	-	TAG2	TAG3	TAG3	TAG3	TAG3	TAG3	
difference [(G)-(F)]	kW	Actual limit	1,921	1,614	1,388	319	-21	-275	
Unit capacity of peak load :									
Variation : corresponding unit	-	-	G301	G301	G301	G301	G301	G301	
unit capacity	kW	Actual limit	27,500	30,000	30,000	30,000	30,000	30,000	
frequency variation	Hz	-	1.5	1.6	1.6	1.4	1.4	1.4	Power constant : 1%MW/0.1Hz
Allowable unit caapcity : ≦1Hz	kW	-	18,190	18,710	19,100	20,990	21,610	22,080	
≦2.5Hz	kW	-	45,475	46,775	47,750	52,475	54,025	55,200	Activation of load shedding (3rd)
Unit capacity of off-peak load :									
Variation : corresponding unit	-	-	G301	G301	G301	G301	G301	G301	
unit capacity	kW	Actual limit	16,500	18,000	18,000	18,000	18,000	18,000	estimated as 60% of rated
frequency variation	Hz	-	1.8	1.9	1.9	1.7	1.7	1.6	Power constant : 1%MW/0.1Hz
Allowable unit caapcity : ≦1Hz	kW	-	9,095	9,355	9,550	10,495	10,805	11,040	
≦2.5Hz	kW	-	22,738	23,388	23,875	26,238	27,013	27,600	Activation of load shedding (3rd)

Source : statistical operation record by SENELEC (August 1994)
Estimation of peak generation of Kaolack : 1994 = 10.7MW, 1995 = 11.2MW, 1996 = 11.6MW

Table 6.3.2-3 Annual Energy Production by Annual Operation Time

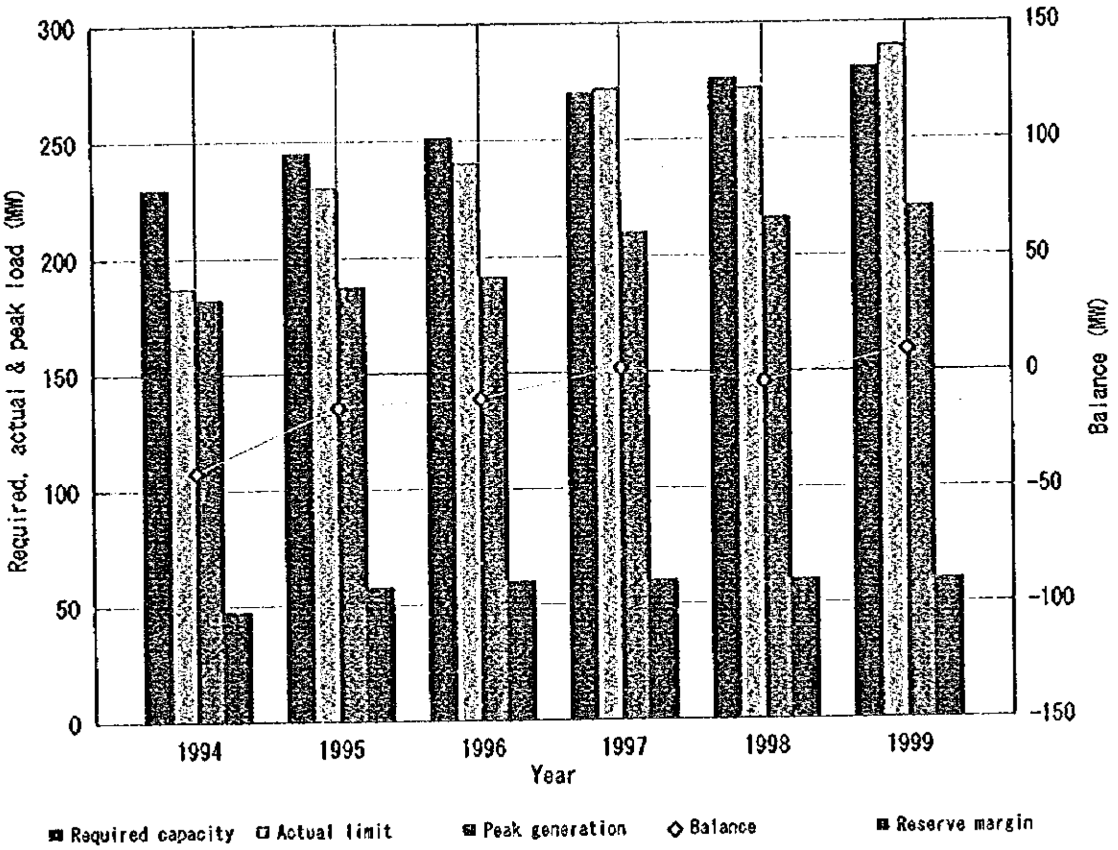
Unit	Capacity in 1994			1994			1995			1996			1997			1998			1999			Remarks
	Rated	Actual limit	Average output	Energy production (GWh)			Energy production (GWh)			Energy production (GWh)			Energy production (GWh)			Energy production (GWh)			Energy production (GWh)			
				AOT1	AOT2	AOT3	AOT1	AOT2	AOT3	AOT1	AOT2	AOT3	AOT1	AOT2	AOT3	AOT1	AOT2	AOT3	AOT1	AOT2	AOT3	
	MW	MW	%	6,132H	6,570H	7,008H	6,132H	6,570H	7,008H	6,132H	6,570H	7,008H	6,132H	6,570H	7,008H	6,132H	6,570H	7,008H	6,132H	6,570H	7,008H	
Existing facility (GWh)				866.1	928.0	989.9	973.8	1,043.3	1,112.9	1,025.9	1,099.2	1,172.4	1,059.0	1,134.6	1,210.3	1,059.0	1,134.6	1,210.3	1,059.0	1,134.6	1,210.3	
G105	5,000	5,000	90	27.6	29.6	31.5	27.6	29.6	31.5	27.6	29.6	31.5	27.6	29.6	31.5	27.6	29.6	31.5	27.6	29.6	31.5	
G106	5,000	5,000	90	27.6	29.6	31.5	27.6	29.6	31.5	27.6	29.6	31.5	27.6	29.6	31.5	27.6	29.6	31.5	27.6	29.6	31.5	
G101	12,800	5,000	65	19.9	21.4	22.8	39.9	42.7	45.6	39.9	42.7	45.6										
G102	12,800	9,000	65	35.9	38.4	41.0	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	
G103	12,800	11,000	65	43.8	47.0	50.1	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	
G104	12,800	5,000	65	19.9	21.4	22.8	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	39.9	42.7	45.6	
G301	27,500	27,500	85	143.3	153.6	163.8	143.3	153.6	163.8	143.3	153.6	163.8	143.3	153.6	163.8	143.3	153.6	163.8	143.3	153.6	163.8	
G302	30,000	20,000	85	104.2	111.7	119.1	104.2	111.7	119.1	156.4	167.5	178.7	156.4	167.5	178.7	156.4	167.5	178.7	156.4	167.5	178.7	
G303	30,000	15,000	85	78.2	83.8	89.4	156.4	167.5	178.7	156.4	167.5	178.7	156.4	167.5	178.7	156.4	167.5	178.7	156.4	167.5	178.7	
TAG1	16,500	15,000	55	50.6	54.2	57.8	50.6	54.2	57.8	50.6	54.2	57.8	50.6	54.2	57.8	50.6	54.2	57.8	50.6	54.2	57.8	
TAG2	21,500	19,000	55	64.1	68.7	73.2	64.1	68.7	73.2	64.1	68.7	73.2	64.1	68.7	73.2	64.1	68.7	73.2	64.1	68.7	73.2	
G401	20,000	20,000	80	98.1	105.1	112.1	98.1	105.1	112.1	98.1	105.1	112.1	98.1	105.1	112.1	98.1	105.1	112.1	98.1	105.1	112.1	
G402	20,000	20,000	80	98.1	105.1	112.1	98.1	105.1	112.1	98.1	105.1	112.1	98.1	105.1	112.1	98.1	105.1	112.1	98.1	105.1	112.1	
S-L No.1	3,250	3,250	85	16.9	18.1	19.4	16.9	18.1	19.4	16.9	18.1	19.4	16.9	18.1	19.4	16.9	18.1	19.4	16.9	18.1	19.4	
S-L No.2	3,250	3,250	85	16.9	18.1	19.4	16.9	18.1	19.4	16.9	18.1	19.4	16.9	18.1	19.4	16.9	18.1	19.4	16.9	18.1	19.4	
S-L No.3	2,000	2,000	85	10.4	11.2	11.9	10.4	11.2	11.9	10.4	11.2	11.9	10.4	11.2	11.9	10.4	11.2	11.9	10.4	11.2	11.9	
S-L No.4	2,000	2,000	85	10.4	11.2	11.9																
KAO No.1	3,500	3,500	85										18.2	19.5	20.8	18.2	19.5	20.8	18.2	19.5	20.8	
KAO No.2	3,500	3,500	85										18.2	19.5	20.8	18.2	19.5	20.8	18.2	19.5	20.8	
KAO No.3	3,500	3,500	85										18.2	19.5	20.8	18.2	19.5	20.8	18.2	19.5	20.8	
KAO No.4	3,500	3,500	85										18.2	19.5	20.8	18.2	19.5	20.8	18.2	19.5	20.8	
Projected facility (GWh)				0.0	0.0	0.0	67.5	72.3	77.1	67.5	72.3	77.1	210.9	226.0	241.1	210.9	226.0	241.1	299.2	320.6	342.0	
TAG3	20,000	20,000	55				67.5	72.3	77.1	67.5	72.3	77.1	67.5	72.3	77.1	67.5	72.3	77.1	67.5	72.3	77.1	
Diesel SR	10,000	10,000	90										55.2	59.1	63.1	55.2	59.1	63.1	55.2	59.1	63.1	
EXT-CIV	18,000	18,000	80										88.3	94.6	100.9	88.3	94.6	100.9	88.3	94.6	100.9	
EXT-CIV	18,000	18,000	80																88.3	94.6	100.9	
Total energy (GWh)				866.1	928.0	989.9	1,041.2	1,115.6	1,190.0	1,093.3	1,171.4	1,249.5	1,269.9	1,360.6	1,451.4	1,269.9	1,360.6	1,451.4	1,358.2	1,455.3	1,552.3	
Required energy (GWh)				1,063.7	1,063.7	1,063.7	1,095.6	1,095.6	1,095.6	1,127.1	1,127.1	1,127.1	1,167.5	1,167.5	1,167.5	1,202.3	1,202.3	1,202.3	1,238.0	1,238.0	1,238.0	
Balance (GWh)				-197.6	-135.7	-73.8	-54.4	20.0	94.4	-33.8	44.3	122.4	102.4	193.1	283.9	67.6	158.3	249.1	120.2	217.3	314.3	

Output : capacity of actual limit (MW)

AOT : Annual Operation Time, AOT1 : 70%(6,132hour), AOT2 : 75%(6,570hour), AOT3 : 80%(7,008hour)

Capacity G101-G105 : 10,000kW on & after 1995, G303 : 30,000kW on & after 1995, G302 : 30,000kW on & after 1996

Graph 6.3.2 Supply Balance
Short Term Development



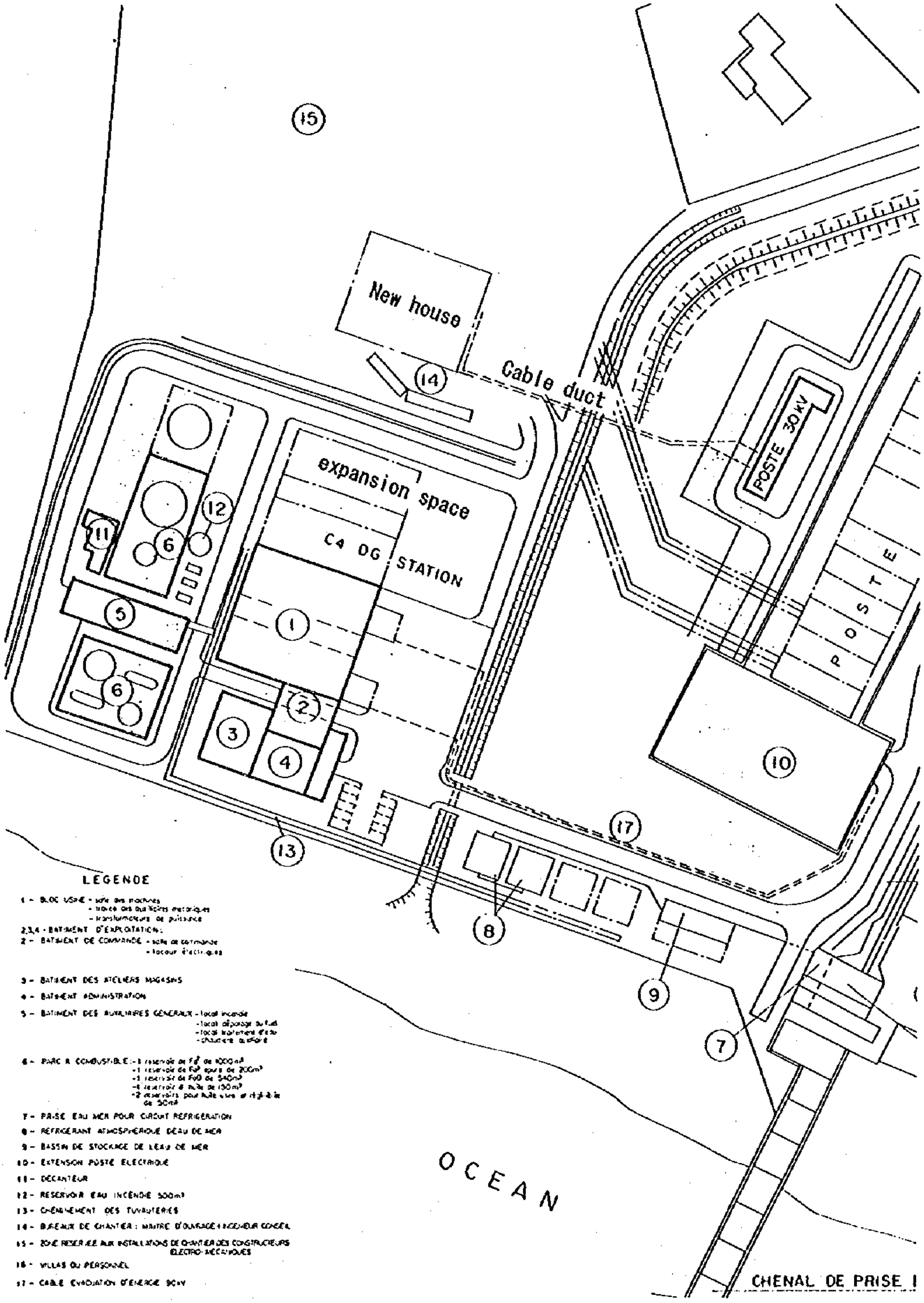


Fig. 6.4-1 Ground Plan of New Diesel House

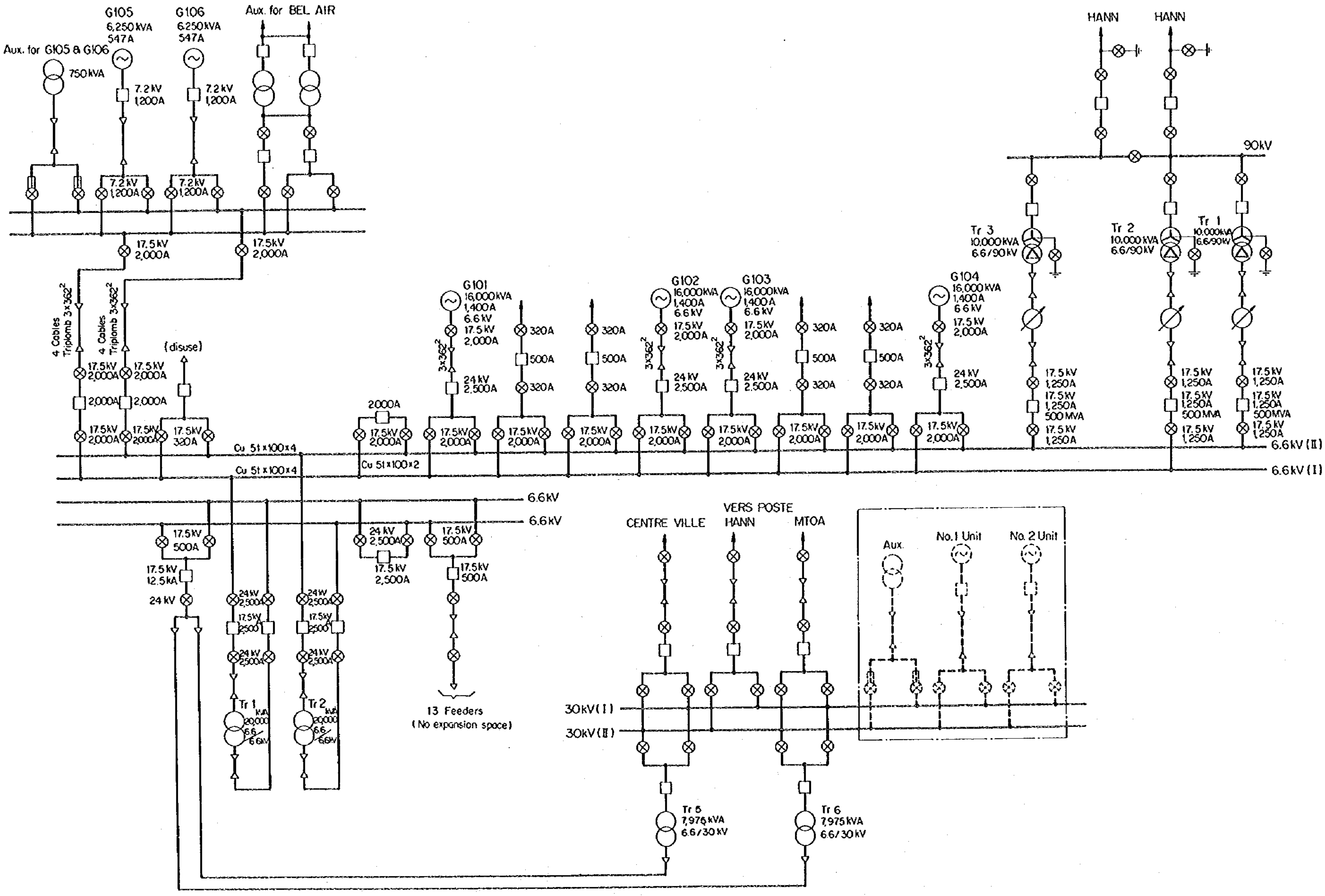


Fig. 6.4-2 SINGLE LINE DIAGRAM (Bel-Air)

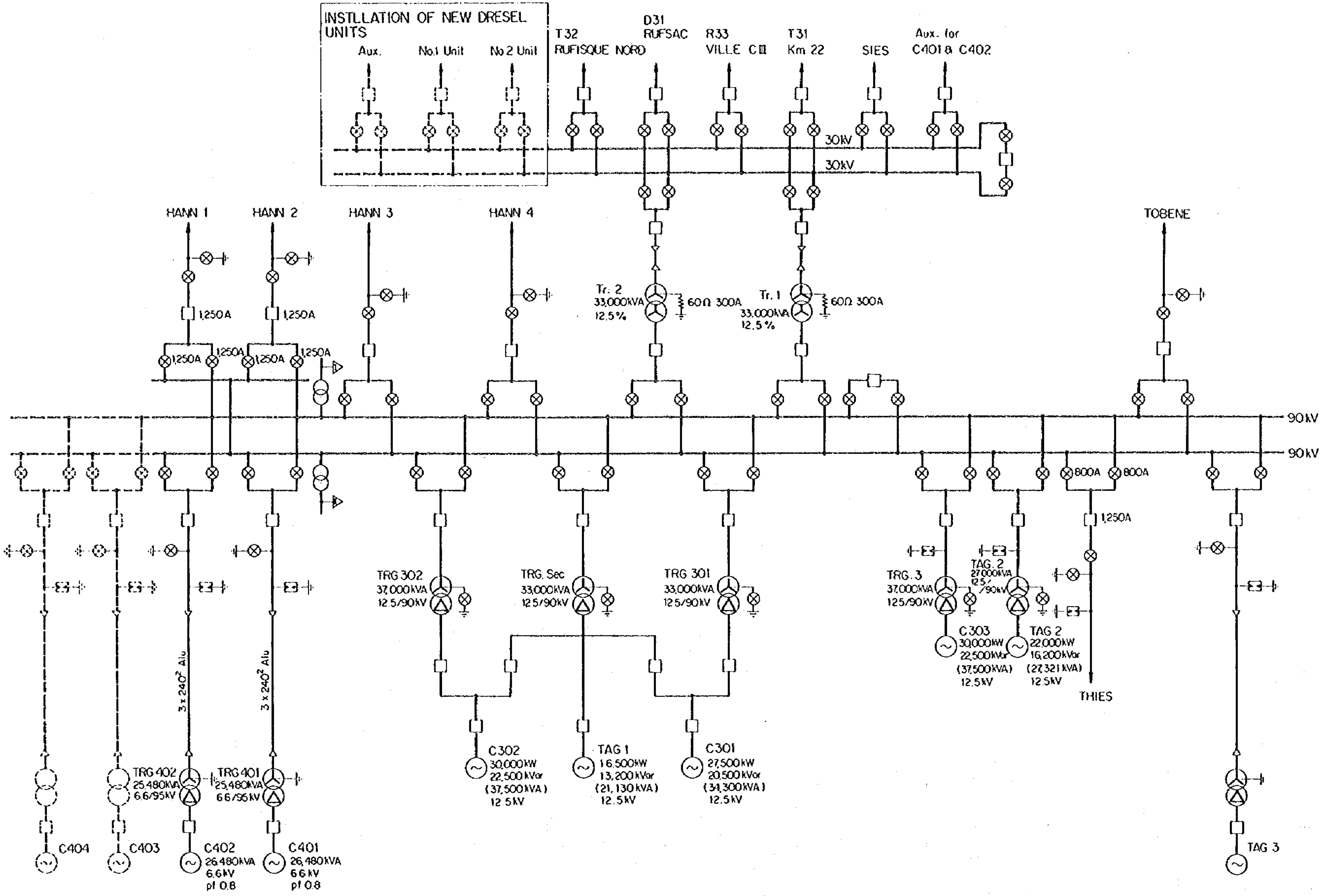


Fig. 6.4-4 SINGLE LINE DIAGRAM (Cap des Biches)

CHAPTER 7

IMPROVEMENT OF DISTRIBUTION NETWORK

CHAPTER 7 IMPROVEMENT OF DISTRIBUTION NETWORK

7.1 Need for Improvement of Distribution Network

SENELEC's existing distribution network in the Dakar area has not received the attention it should have been given in carrying out the appropriate extension, expansion and rehabilitation work to meet the sharp increase of load in the urban area. As a result, bottlenecks are in evidence and extreme voltage drops occur in various parts of the distribution system. These problems are a serious hindrance to the stable, reliable and high-quality power supply to the consumers.

Aging is another big problem as many of the facilities are now over 30 years old, going back to the time when the system was first installed. Obsolescence and capacity shortage are the main causes of frequent disruptions in the form of operating problems and failure of equipment. In general, the situation is that normal operation of the distribution system is seriously impaired.

At the same time, the government of the Senegal and the Dakar city authorities are engaged in population dispersal programs to counter the extremely high population density in central Dakar and the influx or the migrant population from outside Dakar into the city. As part of these programs, housing estates are being built on the outskirts of Dakar. While efforts are being made to create the infrastructure in the suburban areas it has still not been possible to provide the new residential suburbs with adequate power. To resolve these problems on distribution facilities, it is considered most essential to carry out rehabilitation, expansion and other necessary works on the distribution network in order to provide the consumers with a high-quality electric power and to give new consumers the benefits of electricity supply without delay.

7.2 Distribution Line Facility Plan of SENELEC

7.2.1 Operational Problems

Operational problems on transmission and distribution lines of SENELEC are as follows.

(1) 90 kV Transmission Lines

At present, no problems are encountered with the operation of the existing 90 kV transmission lines.

(2) 90/30 kV Grid Substations and 30/6.6 kV Distribution Substations

While there are no problems in connection with the 90/30 kV grid substations and 30/6.6 kV distribution substations, caution is needed on the following aspects relating to the 30/6.6 kV distribution substations.

a. Due to the use of minimum oil type circuit breakers which have aged significantly, it will be necessary to carry out occasional repairs as these breakers are vital to ensure the reliability of grid protection. It is recommended that the existing breakers be replaced with SF6 type circuit breakers in all distribution substations.

b. The batteries are installed on the floor and it is recommended that they be mounted on racks.

(3) 30kV Distribution Network

a. The pole-mounted H61 type Poste transformers are not provided with a lightning arrester. It is recommended that lightning arresters be installed.

b. The section switches installed outdoors are not easy to maintain due to contamination of dust, it would be desirable to install these section switches in an indoor location.

(4) 6.6kV Distribution Network

a. There is not sufficient medium/medium voltage transformer capacity to meet the supply need for consumers through the 6.6 kV system. Steps are therefore promoted to step up the voltage of the 6.6 kV lines to 30 kV to supply power to new consumers through a 30 kV system.

b. The minimum-oil type circuit breakers present difficulties in terms of maintenance and control.

c. Some consumers are supplied through spare cables. These consumers should best be supplied on a 6.6 kV or 30 kV supply voltage.

d. The locking devices are not functioning. To avoid maloperation, it is therefore recommended that these defective devices be replaced.

e. The settings for the fixed time overcurrent relays for the underground cable are inadequate.

f. The Bel-Air distribution substations have no space for extension.

(5) Medium/Low Voltage Poste (Distribution Poste)

It is recommended that lightning arrester and medium-voltage fuses be installed.

(6) Low Voltage Distribution Network

a. To reduce power losses and balance the load between phases, it will be necessary to change the supply voltage to consumers from the "false B2" to "real B2."

b. It is recommended that the bare copper conductors should be replaced with pre-assembled cables.

c. Installations in coastal regions are exposed to salt contamination. To prevent this hazard, underground cables is recommendable.

7.2.2 Planning Standards

The following is an overview of the standards applicable to the Basic Distribution Line Plan and the operation of the distribution lines. These standards have been quoted essentially from the "Master Development Plan (Report 334432-4-84)."

(1) Voltage Classes

The voltage classes used for the distribution lines in the Dakar area are as follows.

- Medium Voltage Distribution Lines: 6.6 kV and 30 kV
- Low Voltage Distribution Lines : 127/220 V (B1/false B2)
  220/380 (real B2)

Under SENELEC's future plan, the standard voltage classes will be:

- Medium Voltage Distribution Lines: 30 kV
- Low Voltage Distribution Lines : 220/380 V

(2) Maximum Allowable Voltage Drop

The maximum allowable voltage drop limits for SENELEC's distribution network have been determined as follows.

- Low Voltage Distribution Lines : ±10%
- Medium Voltage Distribution Lines: 5% (under normal conditions)
  10% (under abnormal conditions)

(3) Maximum Allowable Current

Tables 7.2.2-1 ~ 3 gives the maximum allowable current for conductors and cables. Table 7.2.2-4 shows the maximum allowable current for substation bus bars. The conditions applicable to the calculations are as follows:

a. Conductors

- Ambient temperature : 30 °C
- Temperature rise of conductors : 40 °C

b. Underground cable

- Basic temperature of soil : 30 °C
- Specific heat resistance of soil: 100 °C cm/W

(4) Short circuit Level and Insulation Class

The following specification data have been laid down by SENELEC.

a. Short circuit current

30 kV & 6.6 kV circuit breakers: 12.5 kA
30 kV & 6.6 kV circuit breakers
and disconnecting switches : 10.0 kA

b. Insulation class

6.6 kV: 24 kV (Impulse voltage: 125 kV)
30 kV : 36 kV (Impulse voltage: 170 kV)

In regions liable to salt contamination problems due to air salinity, the insulation classes 45 kV and 60 kV shall be applicable in accordance with the pollution level.

(5) High Voltage/Medium Voltage Substations (Grid Substations)

1) Spare transformer capacity

The spare transformer capacity at the high voltage/medium voltage substations is stated as given below by the number of transformer banks installed in the substation.

a. 100%: 1 bank
b. 50%: 3 banks
c. 33%: 4 banks

2) Limitation on transformer capacity

The table below gives the percent-impedance of transformers on the basis of the short circuit current of medium-voltage distribution lines.

Substation	Percent-Impedance	Rated Capacity
High voltage/30kV (Grid substation)	12.5%	80MVA
30/6.6kV (Distribution substation)	11.0%	20MVA
30/6.6kV (Distribution substation)	10.0%	15MVA

3) Guaranteed capacity for substations

The guaranteed capacity data for injector substations with two and three transformer units are as follows.

Unit: MVA

Type of substation	2 Transformers		3 Transformers	
	Installed capacity (MVA)	Guaranteed capacity	Installed Capacity (MVA)	Guaranteed capacity
High voltage/30kV	2x40	40	-	-
High voltage/30kV	2x80	80	3x80	160
High voltage/30kV	2x40+1x80	80	1x40+2x80	120
30/6.6kV	2x15	15	3x15	30
30/6.6kV	2x20	20	3x20	40

4) Number of feeders

The maximum values for the medium-voltage feeders required for high voltage/medium voltage substations (Grid Substations) shall be calculated on the basis of the mean load factor during peak load conditions and the inter-feeder expansion factor (facteur de foisonnement). (For details concerning the method for calculating the expansion factor, refer to Report Document No. 34432-4-84.) This expansion factor has been applies to the cross-sectional area of the conductors and the guaranteed capacity data for substations to obtain the following values for the number of feeders required.

Type of substation	Feeder		Supply substation	Number of feeder		
	Rated capacity (MVA)	Mean load (MVA)	Guaranteed output (MVA)	For operation	Spare	Total
High voltage/ 30kV	15.3	7.6	40 80 120 160	7 13 19 25	2 4 6 7	9 17 25 32
30/6.6 kV	4.4	2.9	15 30 40	7 13 17	2 4 5	9 17 22

(6) Medium Voltage Distribution Networks

1) Configuration of the medium voltage distribution networks

The grid configuration of SENELEC's medium voltage distribution network has been standardized on a spike (corn ear) - spindle structure.

2) Supply range of feeders

The feeder lengths for SENELEC's medium voltage distribution networks have been determined as follows,

a. 6.6 kV: Overhead lines : 3.8 km
Underground cables: 5.3 km

b. 30 kV : Overhead lines : 13 km
Underground cables: 21 km

3) Conductor size

Economic conductor sizes for the SENELEC system are as follows.

Transmission/ Distribution	Overhead Lines (ALMELEC)	Underground Cables (AL TORSADE)
a. 6.6 kV Distribution lines		
Trunk lines	148 mm^2	240 mm^2
Branch lines	93.3 mm^2	150 mm^2
b. 30 kV Distribution lines		
Trunk lines	148 mm^2	150 mm^2
Branch lines	93.3 mm^2	95 mm^2
c. 30 kV Transmission lines		
15 MVA Substation	228 mm^2	240 mm^2

4) Medium voltage/low voltage transformer capacity

The decision is that transformers of such a capacity are to be installed at SENELEC that no replacement will be needed for three years after the commissioning of the transformers.

(7) Low Voltage Distribution Lines

1) Voltage drops for low voltage feeders

Maximum voltage drop for low voltage feeders: 5%
(subject to the following conditions)

a. Power factor: 85%

b. No load over the initial 10% section from the distribution Postes and uniform distribution over the remaining sections. Table 7.2.2-5 gives the supply range for the low-voltage distribution lines.

2) Supply range for medium voltage/low-voltage postes (distribution substations) and number of feeders

Table 7.2.2-6 shows the load densities and number of feeders for the transformer capacities concerned, based on the low voltage feeders' load factors. Due to current capacity limitations, the number of feeders will increase when transformers in excess of 630 kVA are used for the overhead line feeders.

(8) Protection

1) Summary

Generally, the distribution network has adequate protection and the protective devices are functioning properly. The protection system using fixed time overcurrent relays is not appropriate for the high voltage and medium voltage grids which require early fault removal in order to reduce grid damage and maintain grid supply reliability.

At the high voltage/30kV substations, it is therefore recommended that inverse time relays be used for the each voltage levels and for the feeders.

2) High voltage/medium voltage postes (grid substations)

The following protective systems are being used in the grid substations.

a. Line protection : Electrostatic distance relays

b. Feeder protection : Overcurrent protection

c. Transformers : Differential relays, gas detector relays, temperature relays

d. Overhead feeders : Overcurrent ground relays

3) 30/6.6 kV postes (distribution substation)

a. 30 kV feeders: Overcurrent relays

4) 30 kV and 6.6 kV feeders

30 kV and 6.6 kV Feeders: Fixed time overcurrent relays

5) Medium voltage/low voltage postes (distribution postes)

a. Primary side of medium voltage/low voltage transformer: medium voltage fuse

b. Low voltage feeders: Fuses

c. Transformers mounted on Poste H61: Circuit breakers installed on secondary side

Transformer and underground cables require protection by lightning arresters.

7.2.3 Long-Term Plan

(1) The State of the Power System in Year 2005

The Study was performed on the basis of the following assumptions.

- By the target year 2005 the transmission voltage in the Study Area will be 90 kV.

- The power generating facilities will be expanded to meet the increases of load.

1) 90 kV transmission lines

Even in case of fault of one circuit transmission line, transmission capacity will be maintained at 262 MVA on the Cap des Biches ~ Hann section and at 181 MVA on the Hann ~ Bel-Air section.

These figures exceed the estimated load of 144 MW (in the high-growth scenario), no 90 kV transmission line will be constructed.

2) High voltage/medium voltage grid substations

Under the optimization survey, the distribution network plan has been drawn up with the objective of creating a network with fully adequate capacity while minimizing construction costs. The conclusion has been reached that it is more appropriate to change over the 6.6 kV load to a 30 kV network and not expand the 6.6 network which has seen a considerable load expansion.

Nor is it considered necessary, with regard to the 30 kV network, to build new high voltage/30 kV grid substations, except where the supply capacity has reached its limits or the supply range is expanding.

Based on the application of this approach, the following conclusions have been drawn. In order to establish an optimum distribution network, it will be possible to meet power demand for the three existing grid substation (Hann, Cap des Biches and Bel-Air) by changing over to 30 kV from the current 6.6 kV load for approximately 28 MVA by the target year, and through the installation of one transformer unit at Hann.

Evolution of loads in the grid substations and change over schedule of 6.6 kV loads to 30 kV are shown in Tables 7.2.3-1 and -3, respectively.

To confirm the targeted distribution network, a distribution network improvement plan has been formulated with the year 2005 as the target year by analyzing the planar shifts of the center of gravity of the loads in each area. As a result, it has been established that the deviation of the plan from the load center is a minor one. This means that no major route change is required to the basic distribution network.

Due to the changeover to the 30 kV distribution network and as a result of increased power demand, it will be necessary to increase the guaranteed output from the grid substation Hann. On the high growth scenario, it is planned to install a 80 MVA transformer at Hann in the period from 1997 to 1998 to replace the 40 MVA transformer.

Technical surveys have shown that the expansion of the medium-voltage distribution network in Dakar is limited by the following factors:

- Bottlenecks
- Excessive voltage drops at feeder ends

The bottleneck problem can be resolved by using standardized cables. The problem of excessive voltage drops at the feeder ends can be resolved by using double circuit feeders or by changing over to a 30 kV system.

3) Conclusions

The targeted grid is to see a gradual transition to 30 kV supply for major loads in order to improve the reliability of the medium-voltage grid and create more favorable operating conditions. With the increase of capacity at the Hann grid substation (1996 - 1997), it will be possible to enhance the guaranteed output from a level of 80 MVA to 112 MVA.

(2) Medium Voltage Distribution Network Plan

1) Priority construction work - 1992

Simulations of the operating conditions for the distribution network built in 1991 demonstrated that there were no major problems on the 6.6 kV distribution network's trunk line end, except for excessive voltage drops and bottleneck conditions.
The voltage drops need to be controlled to within 5% by using 30/6.6 kV transformers.
To resolve the bottleneck conditions, rehabilitation work is required involving the replacement of the small size conductors.
Table 7.2.3-2 sums up the rehabilitation work required on a priority basis in order to resolve these problems.

2) Rehabilitation plan for the Dakar distribution network

Table 7.2.3-4 sums up the short-, medium- and long-term construction plans. Tables 7.2.3-5 ~ 7 present details of the construction projects.

3) Changeover plan for the 6.6 kV distribution lines to 30 kV (voltage step-up)

- The load at the trunk line feeder outlet is to be reduced.
- Operation of the 30/6.6 kV distribution substations is to be continued without increasing transformer capacity.
- Voltage drops are to be controlled to within 5% of the rated voltage.

In view of the above, it will be necessary to use a 30 kV supply voltage for the large consumers.
Table 7.2.3-3 is an overview of the changeover plan for the 6.6 kV load to 30 kV.

4) Distribution network expansion plan

To supply power to new loads it will be necessary to expand the existing distribution lines. In this connection, an estimate has also been prepared for the transformer capacity required to meet the line expansion scheme by breaking down the consumers by category and the supply territory by region.

Table 7.2.3-8 outlines the expansion plan for the distribution network and the transformer capacity requirement.

(3) Overview of the Dakar Distribution Network Implementation Plan

The Distribution Network Plan has been established with a view to achieving a distribution network capable of meeting the demand forecast for the plan's target year 2005.
The guaranteed capacity at each of the substations under the plan is as follows.

a. Grid substation

	(MVa)
- Hann	112 MVA (after replacement of 40MVA tr. by 80 MVA (1996-1997))
- Bel-Air	36
- Cap des Biches	33

b. Distribution substations

	(MVA)
- Centre Ville	16
- Universite	15
- Usine des Eaux	15
- Aeroport Yoff	7.5
- Thiaroye	7.9

Under the above plan, it is believed that the changes to the existing distribution network are of a minimum nature. The rehabilitation plans for the distribution network have been established in order to resolve the bottleneck conditions and the overload problems encountered in the 6.6 kV distribution network. The recommended rehabilitation plan is as shown below.

	1992	1993-1996	1997-2000	2001-2005	Total
Total conductor length (m)	2,000	3,250	2,210	3,450	10,910

The line length required for the distribution network expansion and the changeover to 30 kV is as follows.

	1992	1993-1996	1997-2000	2001-2005	Total
Additional line length required for network expansion and changeover to 30kV (m)	1,500	11,500	14,000	15,000	42,000
Additional line length required for expansion of 6.6kV network (m)	-	6,000	3,000	2,000	11,000
Total	1,500	17,500	17,000	17,000	53,000

(4) Formulation of Development Strategy for the Low Voltage Distribution Network

The distribution lines from the cabin-type medium/low voltage distributions Postes currently being used by SENELEC, have serious disadvantages. They require high investment costs and long low voltage feeders and give rise to considerable ohmic losses and serious voltage drops.

The use of H61 type overhead Postes will permit savings in construction costs. However, for the reasons given below, their use cannot be recommended in the area covered by the present survey.

- Their weight would limit the transformer capacity to 160 kVA.
- Special vehicles and tools would be required for the work.
- It would be difficult to establish the expansion plan (because of the inability to control the load).
- These overhead postes are vulnerable to contamination.
- They make repair work very complicated and difficult.
- Work is under way to lay underground cables for the medium voltage distribution network.

In formulating the development strategy for the low voltage distribution network, it may be wise to lay down the following basic rules.

- Economic load factor for the feeder
- Maximum supply range for the medium/low voltage distribution Postes

- Maximum allowable current for conductors

The following problems will arise unless the above rules are assured:

- The distribution network would be expanded in an unscheduled, unplanned manner.
- Equipment would be operated uneconomically.
- Excessive voltage drops would occur.
- The service life of the equipment would be contracted as a result of overload operation.

(5) Changeover to "real B2" (220/380 V)

SENELEC's standard power supply voltage to low voltage consumers is 220/380 V (real B2), but approximately 50,000 consumers are on a 120/220 V (false B2) supply.

Most cases of feeder overload on the low voltage feeders and most of the major voltage drops occur in the False B2 grid. The False B2 grid also gives rise to the following frequently occurring problems.

- Load imbalance between phases
- Inappropriate load distribution between the distribution postes of the new B2 and the old False B2.

These problems lead to more serious voltage drops in the low voltage network and to increased losses.

(6) Evaluation of Required Low Voltage Distribution Line Facilities in 1993-2005

1) Evaluation of medium voltage/low voltage distribution substations required

From the study results, the loads of 6.6 kV distribution network are satulated, namely the changeover of loads to 30 kV should be promoted in order to keep the supply reliability and the quality of service.

The following overview shows the transformer capacity required in connection with the load changeover to 30 kV.

	1992	1993-1996	1997-2000	2001-2005	Total
30kV/Low voltage Transformer Capacity (MVA)	1,800	8,300	8,100	9,800	28,000

The following overview shows the transformer capacity required for the 6.6 kV distribution network.

	1992	1993-1996	1997-2000	2001-2005	Total
60kV/Low voltage Transformer Capacity (MVA)	-	2,800	3,900	4,200	10,000

2) Forecast needs for the low voltage distribution network

a. Low voltage feeder length

The low voltage feeder length consists of the following elements.

- Transmission length : Distance from the feeder outlet to the first low voltage consumer

- Distribution length : Distance to the other low voltage consumer

Normally, the transmission length is a little short of 10% of the feeder length. The low voltage feeder length, in turn, is a function of the number of consumers supplied and the surface area of the supply territory. The housing density in the supply area can therefore be determined from the length of the low-voltage distribution lines for each low voltage consumers. The results shown in the following table can be obtained by applying this hypothesis to the number of consumers covered by the demand forecast.

Year	Number of low voltage consumers	Length per consumer (m/consumer)	Total low voltage distribution line length (km)	Number of distribution Postes	Length per Poste (km/Poste)
1991	161,521	7.50	1,200	543	2.2
1993	171,430	7.35	1,259	553	2.2
1996	193,950	7.13	1,380	610	2.2
2000	228,644	6.85	1,560	673	2.3
2005	280,866	6.52	1,810	745	2.4

3) Type of low voltage distribution network

In view of the current situation marked by the use of low voltage overhead lines consisting of bare conductors (approximately 370 km), it will be necessary to change the supports for most part to either concrete or wooden poles and the bare conductor to preassembled cables. While the present situation shows that only about 10% of all currently existing facilities use underground cables, the schedule under the plan for the period 1993 - 2005 is to raise this share to 30%. Based on this plan, it is possible to estimate the length of the low voltage distribution network required for the plan period from 1993 through 2005. The results of these estimations are as shown below.

Period	Low voltage distribution line length (km)				
	Extension	Rehabilitation	Total	Overhead lines	Underground lines
1993-1996	159	370	529	510	19
1997-2000	137	-	137	110	27
2001-2005	210	-	210	147	63

(7) Need for Facilities and Investment Plans

1) High voltage transmission network

In the Survey territory, it will not be necessary to construct 90 kV transmission lines by the project target year of 2005.

2) 90/30 kV grid substation

During the period from 1997 - 2000, it will be necessary to change the 40 MVA transformers at the Hann Grid Substation to 80 MVA. The costs involved will be US$907,220.

3) 30/6.6 kV distribution substation

Planned for construction work :

- The minimum-oil type circuit breakers need to be replaced by SF6 breakers (23 sets)
- Installation of racks for storage batteries
- Installation of neutral grounding resistance at Aeroport Yoff distribution substation.

The costs involved will be US$312,450.

4) Medium voltage distribution line network

The construction quantities required for the medium voltage distribution line network is as shown below.

Period	Rehabilitation (km)	Extension (km)	Total (km)
1993-1996	5.5	19	24.5
1997-2000	2.5	17	19.5
2001-2005	3.5	17	20.5

5) Low voltage distribution line network

The construction quantities required for the low voltage distribution line network is as shown below.

Period	Connection joint (Nos)	Medium Voltage /Low Voltage	Line length (km)
1993-1996	29,055	65	159
1997-2000	26,159	63	137
2001-2005	41,913	72	210

This shall be added to the construction for replacing the bare copper conductors by preassembled cables and the construction work for replacing the 293 transformers supplied to the 33,000 consumers receiving power through B1.

The following table shows the investment plan required for the low voltage distribution network. The priority work to be carried out in 1992 is included in the construction work for the period from 1993 to 1996.

Unit: US$

Period	Rehabilita -tion	Extension	Connection joint	Total
1993-1996	16,839,430	6,155,827	4,997,460	27,992,717
1997-2000	-	5,741,244	4,499,348	10,240,592
2001-2005	-	8,313,415	7,209,036	15,522,451

(8) Summary of Investment Plan

The following table sums up the investments required for the distribution network as a whole in the survey territory.

Unit: US$

Period	Grid Substation	Distribu- tion Substation	Medium Voltage Distribu- tion Line	Low Voltage Distribu- tion Line	Total
1990-1996	-	312,450	915,620	27,992,717	29,220,787
1997-2000	907,220	-	747,300	10,240,592	11,895,112
2001-2005	-	-	757,350	15,522,451	16,279,801

7.2.4 Short-Term Plan

The Section describes the implementation plans for rehabilitation, reinforcement and expansion work requiring to be executed on a short-term basis (1993 - 1996). The rehabilitation and reinforcement work to be carried out under this plan addresses the following problem areas in an attempt to improve the line reliability and create greater flexibility in operation.

- Feeder overload
- Excessive voltage drops
- Bottlenecks
- Unsatisfactory overhead lines and underground cables

Also included in this Short-Term Plan are the jobs due to be carried out in 1992.

The following details refer to the priority work to be carried out in 1992 and to the short-term plan to be implemented during the period 1993 - 1996.

(1) 30/6.6 kV Substation

The following construction work is required for the rehabilitation of the injector stations due to be implemented during the period from 1993 until 1996.

1) Replacement of 30 kV and 6.6 kV minimum oil type circuit breakers to gas circuit breakers

Name of Substation	Feeder	Existing breakers	Replacement breakers
Centre-Ville	2 Transformers 2 Transformers 3 Feeders	2 EIB 30kV/630A 2 EIB 20kV/630A 3 EIB 20kV/630A	2 FB4 30kV/630A 2 FB4 6.6kV/1,250A 3 FB4 30kV/630A
Universite	2 Transformers 5 Transformers	2 EIB 30kV/630A 3 EIB 6.6kV/630A 2 DELLE 6.6kV/400A	2 FB4 30kV/630A 2 FB4 6.6kV/1,250A 3 FB4 30kV/630A
Aeroport Yoff	2 Transformers 2 Transformers 1 Feeder	2 EIB 30kV/630A 2 EIB 6.6kV/630A 1 EIB 6.6kV/630A	2 FB4 30kV/630A 2 FB4 6.6kV/1,250A 1 FB4 6.6kV/630A
Thiaroye	4 Feeders	4 DELLE 6.6kV/400A	4 FB4 6.6kV/630A

Objective: Repair of insulation system and reduction of maintenance costs

Costs : US$270,380.-

2) 110 V battery racks installation (under construction as of Feb. 1995)

Reason : Batteries mounted on floor
Costs : US$6,490.-

3) Installation of neutral grounding resistance for two 7.5 MVA transformers units installed at 30/6.6 kV Aeroport Yoff distribution substation.

Reason : Improve protection against grounding fault
Costs : US$35,580.-

(2) 30 kV Line

Construction work under the short-term plan to be implemented on the 30 kV line consists of rehabilitation and expansion.

1) Rehabilitation of 30 kV lines

a. Hann grid substation

Feeder: Hann Pecheurs - Icotaf Substation
Details of work:
Reducing load of Icotaf substation and replacement of existing 350 m long 54.6 mm^2 almelec conductor
Reason: Improvement in operating conditions and clearing bottlenecks
Costs : US$ 12,910.-

b. Cap des Biches grid substation (completed as of Feb. 1995)

Feeders: Rufisque Nord
Details of work:
Installation of lightning arresters on overhead H61 distribution Postes between Keur Daouda Sarr and Sangalkam
Reason: Protection of medium voltage/low voltage (MT/BT) transformers against induced overvoltage
Feeder: km 22

Details of work:

Replacement of equipment on Radio Rufisque distribution Postes

Reason: Aging of equipment

Costs : US$ 1,240.-

2) Changeover to 30 kV

The following (priority) works is due to be carried out on the 30 kV lines in 1992 and in the period 1993 - 1996.

a. Bel-Air grid substation

Feeder: Grand Dakar

Details of work:

Construction of 850 m long 30 kV line and changeover to 30 kV for 2,200 kVA capacity

Reason: To remove the problems of feeder overload and excessive voltage drops

Feeder: Dispensaire

Details of work:

Construction of 1,000 m long 30 kV line and changeover to 30 kV for 500 kVA capacity

Reason: Removing bottlenecks on line and feeder overload problems

Feeder: Yoff

Details of work:

Construction of 300 m long 30 kV line and changeover to 30 kV for 1,000 kVA capacity

Reason: Excessive voltage drops

b. Universite distribution substation

Feeder: Fann

Details of work:

Construction of 250 m long 30 kV line and changeover to 30 kV for 700 kVA capacity

c. Usine Des Eaux distribution substation

Feeder: Puits 12

Details of work:

Construction of 400 m long 30 kV line and changeover to 30 kV for 1,000 kVA capacity

Feeder: Dieupeul Ecole

Details of work:

Construction of 200 m long 30 kV line and changeover to 30 kV for 500 kVA capacity

Reason: Excessive voltage drops

d. Aeroport Yoff distribution substation

Feeder: Air Senegal

Details of Work:

Construction of 450 m long 30 kV line and changeover to 30 kV for 1,000 kVA capacity

Reason: Bottlenecks and feeder overload

Feeder: Batterie Yoff

Details of work:

Construction of 200 m long 30 kV line and changeover to 30 kV for 500 kVA capacity

Reason: Excessive voltage drops

e. Thiaroye distribution substation

Feeder: Route de Rufisque

Details of work:

Construction of 350 m long 30 kV line and changeover to 30 kV for 800 kVA capacity

Reason: Eliminating bottlenecks

Feeder: Yeumbeul (completed as of Feb. 1995)

Details of work:

Construction of 2,500 m long 30 kV line and changeover to 30 kV for 800 kVA capacity (Hamo 4, Hamo 5, Sentenac, Hamo Golf Nord Est)

Feeder: Dagoudane Pikine

Details of work:

Construction of 300 m long 30 kV line and changeover to 30 kV for 600 kVA capacity

Reason: Excessive voltage drops

Feeder: Labo-Pecherie

Details of work:

Construction of 1,000 m long 30 kV line and changeover to 30 kV for 500 kVA capacity

Reason: Excessive voltage drops

3) Expansion of 30 kV lines

In the period 1993 - 1996 it will be necessary to construct 6km overhead lines and underground lines.

This work is required as part of the City Development Project, notably the Development of the Northern Area for the International Trade Fair and the Zac, M'Bao, Malika area development schemes. The new construction will cost an estimated US$249,396.-

(3) Medium Voltage/Low Voltage Substations

In the period 1992 - 1996, 13 MVA load will be increased to the 6.6 kV and 30 kV grid. To supply those load, 50 sets of 30 kV/low voltage transformer and 16 sets of 6.6 kV/low voltage transformers will be required. The costs of these medium voltage/low voltage distribution substation (poste) are estimated as US$2,562,790.-

(4) 6.6 kV Lines

1) Priority work (1992)

Priority works is estimated as US$33,460.- Priority work in the form of rehabilitation work on the 6.6 kV grid consists of the following.

a. Bel-Air grid substation

Feeder: Yoff

Details of work:

Replacement from 22 mm^2 bare copper conductor to 148 mm^2 almelec for distribution Poste HLM ON 13 - Douane (500 m) and Puits 14 - Bassam (200 m) sections.

Reason: Bottlenecks

Feeder: Grand Dakar

Details of work:

Replacement from 22 mm^2 bare copper conductor to 148 mm^2 almelec for distribution Poste Sicap Rue 10 - Freres Canadiens (100 m) and Lotissement-Baobab (250 m) sections.

Reason: Bottlenecks

b. Centre Ville distribution substation

Feeder: Credit Foncier

Details of work:

Replacement from 22 mm^2 bare copper conductor to 148 mm^2 almelec for distribution Poste Credit Foncier - Centre Culturel (75 m) and Centre Culturel-Vox (100m) sections.

Reason: Feeder overload

c. Usines des Eaux distribution substation

Feeder: Puits 12

Details of work:

Replacement from 38 mm^2 bare copper conductor to 148 mm^2 almelec for distribution Poste Puits 12 - Bourguiba (400 m) and from 22 mm^2 bare copper conductor to 148 mm^2 almelec for section Imas - Gras (375 m).

Reason: Bottlenecks

2) Rehabilitation of 6.6 kV lines (1993 - 1996)

In the period 1993 - 1996, rehabilitation work is to be carried out on the 6.6 kV grid and the cost estimates for this work are given as US$53,540.-
The rehabilitation work to be carried out on the 6.6 kV grid in the period 1993 - 1996 consists of the following jobs.

a. Bel-Air grid substation

Details of work:

Replacement from 38 mm^2 bare copper conductor to 148 mm^2 almelec for distribution Poste Puits 12 - Bourguiba (400 m) and from 22 mm^2 bare copper conductor to 148 mm^2 almelec for section Imas - Gras (375 m).

Reason: Bottlenecks and Overloads

Feeder: Dispensaire

Details of work:

Replacement from 50/10 conductor (200 m) and 38 mm^2 bare copper conductor (150 m) to 150 mm^2 almelec for distribution Poste Route des Brasseries - SPAC section.

Reason: Bottlenecks and overload

b. Centre Ville distribution substation

Feeder: Foncier Zola

Details of work:

Replacement from 22 mm^2 bare copper conductor (100m overhead line) to 150 mm^2 underground cable (aluminium) for distribution Poste Consulat - Anse Bernard section.

Reason: Bottlenecks

c. Universite distribution substation

Details of work:

Replacement from PILC 25 undereground cable (700m) to 93.3 mm^2 almelec for distribution Poste Fann Nord - Residence Corniche section.

Reason: Bottlenecks

d. Aeroport Yoff distribution substation

Feeder: Air Senegal

Details of work:

Replacement from 22 mm^2 bare copper overhead line (1,250 m) to 148 mm^2 almelec for branch Terme Nord - branch point Forage Camp Penal section.

Reason: Bottlenecks

e. Thiaroye distribution substation

Feeder: Route de Rufisque

Details of work:

Replacement from 38 mm^2 bare copper overhead line (650 m) to 148 mm^2 almelec.

- Ditribution Poste PTT and Tiaroye - Mer section (500 m)
- Branch point Touba Thiaroye - Poste Touba Thiaroye section (150 m)

Reason: Feeder overload

3) Expansion of 6.6 kV line (1993 - 1996)

In the period 1993 - 1996, it will be necessary to construct a total of 6km of 6.6 kV distribution lines, both overhead and underground lines. In particular, 6.6 kV line is needed in the area west of the Hann grid substation, covering the range Poste Aeroport Yoff and Poste Universite. The construction costs for this work are roughly estimated as US$252,234.-

(5) Low Voltage Lines

The following details refer to rehabilitation work to be carried out on the low voltage lines.

1) Zone: Pikine - Guediawaye - Rufisque areas
In the order of priority, the work breaks down as follows:

a. Pikin (area 2), (Thiaroye, Mer and Dagoudane Pikine feeders)

Replacement of 75 km of low voltage bare conductors by preassembled cables.

b. Parcelles Assainies (No. 1 - No. 6 area)

Rehabilitating 50 km low voltage distribution lines using wooden poles.

c. HLM (New Housing Estates) Guediawage

Rehabilitation of 250 m low voltage underground cables.
Rehabilitation of 250 m underground cables for street lighting.

d. Traditional villages (Thiaroye, Diameguene, Yeumbeul, Keur Massar, M'Bao)

Replacement of 50 km of low voltage bare conductors by preassembled cables.

e. Rufisque

Replacement of 30 km of low voltage bare conductor by preassembled cables.

2) Zone: Dakar - Ville area

a. Medina

Rehabilitation and replacement of 80 km of low voltage bare conductors by preassembled cables.

b. Parcelles Assainies

Rehabilitation of 15 km low voltage distribution line using wooden poles.

c. Traditional villages and SICAP (N'Gor, Yoff, Dakar, Ouakam)

Replacement of 80 km of low voltage bare conductor by preassembled cables.

d. Dakar - Plateau

Replacement of 30 km of low voltage bare conductor by preassembled cables.

The low-voltage distribution lines qualifying for rehabilitation work total 370 km. Moreover, 159 km of low-voltage distribution lines have to be newly constructed to supply power to the development areas (ZAC de M'Bao, Parcelles Assainies de Malika etc.), with plans of new connections to a total of 29,055 consumers.

The construction costs are detailed below.

Rehabilitation	:	US$6,771,930.-
New Installations	:	US$3,593,037.-
Connecting to consumers	:	US$4,997,460.-

(6) Change in Supply Voltage

Supply voltage is to be changed from B1 (127/220V) to B2 (220/380V). The objective is to improve the quality of power supply to the consumers and reduce technical losses as voltage drops will be reduced. The construction work for changing the supply voltage will be as detailed below.

- Replacement of transformers in medium voltage/low voltage poste;
- Public lighting distribution panel (EP);
- Replacement of bulbs for public lightings;
- Change of lead-in connections to False B2 consumers;
- Installation of grounding wires;
- Adaptation of consumer equipment to suit voltage change;
  - Replacement of bulbs
  - Installation of auto-transformers for single voltage units
  - Replacement of single-phase equipment
  - Change of connections for three-phase motors
  - Adaptation of three-phase motor control
  - Replacement of consumers' low voltage cables
  - Changeover to a.c. (three-phase) voltage supply contracts with consumers
  - Replacement of meters and breakers

Area	Number of Postes	Number of Consumers on B1 Supply	Number of Consumers on B2 Supply	Total Number of Consumers
Pikine	50	1,947	20,795	22,742
Dakar	293	16,977	15,813	32,790

A total of 293 distribution Postes and 32,790 consumers will be affected. These will be divided into 58 lots. The costs amount to approximately US$10,067,500.- One lot comprises approximately 5 Postes.

(7) Investment Overview

The total investment costs for the rehabilitation, voltage step-up, and new distribution network construction (expansion) schedules for Dakar and its surrounds under the short-term plan amount to an estimated US$29,220,787.-

These costs are detailed as follows.

	Rehabilitation (US$)	Expansion (US$)	Total (US$)
Injector Substation 30/6.6kV	312,450	-	312,450
30kV network	22,190	554,196	576,386
MT/BT Poste	-	2,562,386	2,562,790
6.6kV network	87,000	252,234	339,234
Low voltage distribution network	16,839,430	8,590,497	5,429,927
Total	17,261,070	11,959,717	29,220,787

7.3 Selection of Priority Works for Improvement

7.3.1 Selection of Priority Works for Improvement

As has been stated in clause 4.6 in connection with Service Interruption due to Faults, it is clear that with respect to supply restriction energy due to faults in the medium voltage distribution lines (30 kV and 6.6 kV):

a. The main factors are:

Problems caused by failure of equipment, rain and the protective system. These problems account for about 70% of all supply restriction energy and are primarily due to the obsolescence and aging of the distribution facilities.

b. The faults by type of failure of equipment are:

Problems occurring with the power cables and insulators. These problems account for about 40% of the supply restriction energy. Similarly to a. above, the main cause for these problems is the obsolescence and aging of the distribution facilities.

It has also been pointed out in Section 12.2 'Distribution Line Facilities' of Chapter 12 'Environmental Assessment' that the existing distribution facilities in the Dakar area suffers from problems, including primarily:

a. Corrosion of the supports
b. Crack formation in the concrete poles
c. Pin corrosion (insulators).

If the distribution facilities is left in its present condition, the consequences may be faults affecting the future distribution facilities and a threat to the safety of the residential population in the area.

Recognizing the present situations of the existing distribution facilities as described above, SENELEC has drawn up a master plan for improving the facilities. Under this plan, the priority works of improvement have been identified and selected for the short-term plan to be implemented on a short-term basis within the schedule for rehabilitation work. However, the present situation is that these improvements have not been carried through as scheduled. Some work had been started but was suspended because of lacking of materials. In view of the problems associated with the operation of the distribution facilities and the difficulties of assuring a reliable power supply, a review is currently being carried out to reassess the scope of work under the short-term plan.

To resolve and improve the above problems on the existing distribution facilities, if only in part, the following areas have been selected as receiving priority under this study.

a. Replacement of circuit breakers
b. Improvement of medium voltage distribution lines
c. Expansion of low voltage distribution network
d. Rehabilitation of low voltage distribution network

7.3.2 Consideration for the Plan

Geographic reference materials indicate that the SENEGAL can be divided into the following climate zones.

a. Sudanese climate (Climat soudanien)

b. Sahelian climate (Climat sahelien)
c. Coastal climate (Climat cotier)
d. Subguinean climate (Climat subguinien)

The target areas for the this Project are the City of Dakar and its surrounding parts. These areas fall within the coastal climate zone above which is characterized by cool, humid north-north-easterly trade winds blowing from December to June. These trade winds carry with their humidity a high level of salinity from the sea which is the source of salt contamination and damage in the Dakar area. As the insulation design of the electric facilities is particularly dependent on the pollution level, it will be important to investigate the extent of pollution level. As will also be stated in Chapter 12, SENELEC's facilities have already suffered damage due to salt contamination. The current damage due to salt contamination situation is as follows:

- Corrosion of the H-section steel used as supports of the distribution lines.
- Pin corrosion of the pin insulators
- Flash-over breakdown of the insulators
- Corrosion of the hardwares

To control the above damage to the distribution facilities, it will be important to exercise the greatest care in using the most appropriate insulation design of the equipment and in selecting the materials. At the same time, the following measures are of great importance in the operation and maintenance of the existing facilities.

- Washing the insulators of the existing facilities.
- Using hot-dip galvanized hardwares.
- Using concrete poles, and steel poles protected against salt contamination.
- Using anti-pollution insulators, etc.

For reference, Table 7.3.2-1 gives guide values for the surface leakage distance of insulators with respect to each pollution level.

7.4 Improvement Plan of Distribution Line Facilities

7.4.1 Replacement of Circuit Breakers

(1) Present Situation and Problems

SENELEC is engaged in a program designed to replace the aged and obsolete oil circuit breakers in a systematic manner so as to upgrade the supply reliability from the distribution substations and in order to reduce maintenance costs. While efforts have been made, there are still some breakers which have not been replaced. These hamper the effective operation of the facilities and impair the reliability of power supply.

Faults or maintenance of the circuit breakers take time and thereby have a significant adverse effect on the power supply. And the manufacturer of old type of circuit brreakers stopped the supply of spare parts for maintenance. Therefore, in order to improve the reliability of power supply from the distribution network, it will therefore be essential to replace these circuit breakers on a very urgent basis.

(2) Selection of Circuit Breakers to be Replaced

The aged and obsolete oil circuit breakers in the distribution substations shall be replaced with gas circuit breakers. Figs. 7.4.1 -1 (1/4 ~ 4/4) show the circuit breakers due to be given priority in replaced at the distribution substations, and Tables 7.4.1-1 (1/4 ~ 4/4) show the specificaiton of existing circuit breakers.

1) Centre Ville

a. No. 1 Transformer (Primary side)
b. No. 2 Transformer (Primary side)
c. Hotel Nina
d. Residence Cap-Vert
e. Foncier Zola
f. Credit Foncier

g. Mohammed V Carnot

2) Universite

a. No. 1 Transformer (Primary side)
b. No. 2 Transformer (Primary side)
c. Fann
d. Mermoz
e. Pointe E
f. Secours Mermoz
g. Abass N'Dao

3) Aeroport Yoff

a. No. 1 Transformer (Primary side)
b. No. 2 Transformer (Primary side)
c. No. 1 Transformer (Secondary side)
d. No. 2 Transformer (Secondary side)
e. Batterie Yoff

4) Thiaroye

a. Icotaf
b. Dagoudane Pikine

7.4.2 Improvement of Medium Voltage Distribution Lines

(1) Present Situation and Problem

At present, the following problems on SENELEC's medium-voltage distribution network will be singled out as requiring an early solution.

a. In some parts, rehabilitation or extension work has not been carried out for expanding the power distribution network. The current capacity of these conductors and underground cables is not adequate and cause bottlenecks in the operation of the distribution network.

b. Overload of the 6.6 kV Distribution Line

At present, the voltage of 6.6 kV and 30 kV is employed as a system voltage for medium-voltage distribution networks. With the future expansion of the medium-voltage distribution network, however, the schedule is not to expand the 6.6 kV distribution network but rather use it in its present form. To meet the future increase in demand, however, the 30 kV distribution system should be expanded instead. Consequently, the 30/6.6 kV transformer load which is currently overloaded will need to be changeovered to 30 kV system.

At the Thiaroye substation, in particular, the situation is that as a result of the increasing 6.6 kV load, SENELEC is no longer in a position to uphold its basic operating criteria of having one spare transformer on standby, as can be seen from Table 7.4.2-1.

c. Replacing of Overhead Lines with Underground Cables in the Urban Areas

In the inner city areas with a large population concentration, the presence of overhead distribution lines is causing safety problems for the local inhabitants and to the environment. These overhead lines are required to replace with underground cables in these densely populated city areas.

d. Overhead Distribution Lines in the Harbor Facilities

In the harbor facilities there are heavy traffic with large trailers frequently coming and leaving. Accident reports indicate that as these trucks move on the harbor site, they will occasionally hit the poles. To avoid such side collision, the bottom parts of the poles are protected by concrete. The fact at present is, however, that accidents due to vehicles brushing the poles cannot be prevented. In the interests of maintaining a stable power supply and of ensuring the safety of vehicles, the overhead distribution lines in the harbor facilities should be replaced with underground cables.

e. Salt Contamination Countermeasures

In certain areas by the coast, salt contamination has resulted in damage to the supports of overhead distribution lines. To prevent these problems, it is recommended that the overhead distribution lines in the zones liable to salt contamination should be replaced with underground cables.

(2) Selection of Priority Work and Present Situation

In view of the difficulties causes to the operation of the distribution facilities and in consideration of the safety aspects, the work to be given priority at present in execution should be identified. The following works have been selected for each substations and the current situation is given below.

Figs. 7.4.2-1 and -2 give the scope of the work to be performed, and Figs. 7.4.2-3 (1/6 ~ 6/6) show the general information of existing facilities to be performed.

1) Bel-Air

a. Feeder Dispensaire
Frequent accidents reported in the Bel-Air harbor facilities, due to large trucks brushing the poles.

2) Thiaroye

a. Feeder Rte. de Rufisque
b. Feeder Labo Pecherie
c. Feeder Dag. Pikine
d. Feeder Yeumbeul

To reduce the 6.6 kV load in the Thiaroye distribution substation, a part of 6.6 kV load will be changeovered to 30 kV system. In the section between Poste Alkarim -

Dispensaire Dominique, the 6.6 kV overhead distribution lines shall be replaced with underground cables because of the high-density housing lots.

3) Universite

a. Feeder Fann

The trees along the roads are growing and it will not be possible to maintain the necessary clearance between the trees and the overhead lines by pruning and cutting the trees back alone. Consequently, underground cables should be used only between the Fann Rue 1 - Fann Nord.

4) Aeroport Yoff

a. Feeder Batterie Yoff

To prevent damage due to salt contamination, underground cables should be used.

(3) Description of Work

The existing 6.6 kV overhead distribution lines shall be replaced by 30 kV underground cables. Line length to be performed for each feeder is as follows.

a. Feeder Dispensaire:	2,150 (m)
b. Feeder Dag. Pikine:	800 (m)
c. Feeder Fann:	350 (m)
d. Feeder Rte. de Rufisque (1):	5,800 (m)
e. Feeder Rte. de Rufisque (2):	6,300 (m)
f. Feeder Dag. Pikine:	1,700 (m)
g. Feeder Batterie Yoff:	2,000 (m)
h. Feeder Labo Pecherie:	2,900 (m)
i. Feeder Yeumbeul (1):	300 (m)
j. Feeder Yeumbeul (2):	750 (m)
Total	23,050 (m)

Table 7.4.2-2 shows the capacity of 6.6 kV transformers to be changeovered to 30 kV system.

7.4.3 Expansion of the Low Voltage Distribution Network

(1) New Housing Estates

To meet the growing demand for houses due to the natural population growth in the Dakar area and population migration from the outer regions into the city, the Senegalese government and the City of Dakar authorities are engaged in development programs to build new housing estates on the outskirts of Dakar. Table 7.4.3-1 gives the names of the new housing development zones scheduled for construction as of September 1994 and lists the development land areas involved and the number of houses to be constructed.

The table indicates that a total of 79,000 new houses are due to be built. It will be SENELEC's mission and obligation to assure the stability of a high-quality power supply to these households. For this purpose, it will be necessary to construct a distribution network consistent with the house construction programs.

(2) Selection of the Regions due for Expansion and their Present Condition

As shown in Table 7.4.3-1, programs are under way to build new housing estates on the outskirts of Dakar, and it will be essential to construct a well-planned distribution network for these new housing zones.

However, in the peripheral zones of Dakar, there still are many housing estates where the residents live without power supply or power supply is not sufficient to meet their demand due to the lack of distribution network. There is a strong desire for reliable power supply in these areas, and it is considered that illegal connection to their houses is motivated by this desire. In the residential areas, the peak load appears in the night-time hours, due primarily to the demand for lighting. Thus, for example, in Madieng-Khary-Dieng, the voltage in the peak load time has been measured as 160 V a value significantly short of the rated voltage of 220 V. This corresponds to an approximately 27% voltage drop. Such excessive voltage drops have a serious adverse effect on electric household appliances, resulting in lower efficiency of equipment and a shorter service life. Fig. 7.4.3-1 shows the voltage characteristics of an incandescent lamp and Fig. 7.4.3-2 the same behavior of a fluorescent lamp. It can be seen from either of these figures that excessive voltage drops make themselves felt in a serious fall in lighting efficiency. For fluorescent lamps, in particular, the effect of voltage drops becomes apparent in a reduced life of the lighting fittings.

In view of this fact, there is a sense of encouragement in the hope that as a result of the expansion of the low voltage distribution network and with the assured supply of a reliable high-quality power to these households it will be possible:

- to upgrade the level of activity of the residents.
- to reduce the illegal connection.
- to make more efficient use of energy.
- to assure the security to the residents at night time.

Consequently, the areas due for construction work to extend the low voltage distribution network are the following five regions so as to bring the benefits of electricity to some areas which have been on a waiting list of as long as five years. Present situation of these areas is as follows.

a. Madieng-Khary-Dieng

- While this area has already been electrified in part (380/220 V), the voltage drops to approximately 160 V during peak demand.
- Water and telephone services are already available.
- There are problems in terms of assuring safety at night.

b. Route de Boune

- There are problems in terms of assuring safety at night.
- Power is supplied in part, but only to special customers.

c. Route de Marine

- Water and telephone services are already available.
- While this area has already been electrified in part (380/220 V), the voltage drops to approximately 175 V during peak demand.

d. Route de Malika

- Power supply is available to a part of this area (380/220 V)

e. Malika

- While this area has already been electrified in part (380/220 V), the voltage drops to approximately 200 V during peak demand.

(3) Outline of Plan

Figs. 7.4.3-3 (1/2 ~ 2/2) give the areas selected for the construction work to extend the low voltage distribution network. The land area due for development and the number of consumers have been estimated as stated below.

Land area for development and number of consumers

		Area (ha)	Consumers (Nos)
a.	Madieng-Khary-Dieng	40	800
b.	Route de Boune	50	1,000
c.	Route de Marine	40	800
d.	Route de Malika	40	800
e.	Malika	50	1,000
	Total	220	4,400

7.4.4 Rehabilitation of the Low Voltage Distribution Network

(1) Current State of the Existing Low Voltage Distribution Network

As will also be stated in Section 12 "Environmental Assessment", the power facilities in the Dakar area have suffered extensive salt contamination damage manifest in the form of corrosion of the materials and insulator flash-over.

As mentioned in section 4.6 "Service Interruption due to Faults", faults on the low voltage distribution lines occur predominantly on the line itself and are caused mainly by line breakage due to aging and bad connection of conductors.

The distribution facilities near the coast use H-section steel for their supports. As these steel parts have very badly corroded it is only too apparent that they are no longer capable of providing the necessary strength to function as supports. For the overhead lines, observation has likewise shown the presence of corrosion of the conductors. This corrosion is the cause of conductor breakage. In some cases, the inadequate strength of the supports will result in their collapse or in conductor breakage during abnormal weather conditions. Incidents of this nature are a direct threat to the safety of the residents.

Forced to undertake improvement work on the existing facilities as a matter of prime urgency.

SENELEC is currently engaged in a rehabilitation work program but the construction work is not being carried out as schedule due to the lack of materials. It is therefore of considerable importance to carry out the improvements of the existing facilities with the greatest urgency in order that SENELEC may meet is obligations of maintain a stable high-quality power supply to the consumers in its supply area and in order to remove the dangers caused to the residents with the existing facilities.

(2) Selection of the Areas for Rehabilitation Work

The following areas will be selected as qualifying for priority in the execution of rehabilitation work. The existing facilities in these candidate areas have been in service for many years since the system was first built and the effects of salt contamination are prominently in evidence as corrosion has proceeded to a significant extent.

a. Base II
- Rue 10
- El Monsour
- Rue 10 x 11
- Rue 10 x Bene
- Canal IV
- Amite II

b. Base III
- Yoff Layenes
- Yoff Centre
- Yoff Village
- N'Gor
- Ouakam Boulga
- Ouakam Taglou
- Ouakam Ecole

(3) General Description of the Materials Used on the Existing Facilities

The following materials are currently used on the existing facilities.

a. Supports
- Wooden pole
- H-section steel

b. Conductors
- Preassembled cable (now being replaced as part of the rehabilitation work)
- Bare copper wire (30/10, 40/10, 50/10, 22 mm^2 38 mm^2)

c. Insulators - Low voltage pin insulators, low voltage tension (dead-end) insulators

(4) Outline of Plan

Figs. 7.4.4-1 (1/3 ~ 3/3) show the existing distribution networks for the Yoff Village, N'Gor and Ouakam areas which qualify for priority in the execution of the rehabilitation work.

The nature of the rehabilitation work under this plan envisages primarily the replacement of the corroded H-section steel and the aged bare copper wires by preassembled cable.

Table 7.2.2-1 Electrical Characteristics of Conductors and Cables (6.6 kV)

Type of Conductor	Line Impedance R1 (ohms/km)	Line Impedance X1 (ohms/km)	Charging Capacity (kVAr/km)	Allowable Current Normal (A)	Allowable Current Abnormal (A)
Underground Cables					
PI 3 x 10 Cu	2.260	0.155	---	80	88
PI 3 x 14 Cu	1.560	0.155	---	90	99
PI 3 x 25 Cu	0.858	0.148	3.004	125	138
PI 3 x 35 Cu	0.618	0.140	3.431	150	165
PI 3 x 116 Cu	0.178	0.110	5.515	300	330
PI 3 x 147 Cu	0.148	0.106	6.041	345	380
PI 3 x 185 Cu	0.120	0.103	6.600	400	440
PI 3 x 240 Cu	0.094	0.098	7.141	470	517
PI 3 x 50 Cu	0.456	0.126	3.960	180	198
PI 3 x 95 Cu	0.228	0.113	5.126	270	297
PI 3 x 120 Cu	0.180	0.110	5.584	315	347
PI 3 x 150 Cu	0.148	0.106	6.050	350	385
PRC 3 x 50 Cu	0.456	0.122	3.004	225	275
PRC 3 x 95 Cu	0.228	0.113	3.692	335	415
PRC 3 x 150 Cu	0.148	0.105	4.400	420	512
PRC-TOR 50 Al	0.756	0.145	3.004	160	195
PRC-TOR 95 Al	0.378	0.131	3.692	230	285
PRC-TOR 150 Al	0.243	0.123	4.400	295	360
PRC-TOR 240 Al	0.148	0.115	5.313	385	485
Conductors					
17 Cu	1.058	0.380	0.132	120	150
22 Cu	0.818	0.371	0.137	145	180
38 Cu	0.474	0.356	0.144	200	250
74 Cu	0.243	0.334	0.152	300	375
2 x 38 Cu	0.237	0.305	0.167	370	460
54.6 Almelec	0.604	0.410	1.585	190	238
93.3 Almelec	0.354	0.380	1.695	275	344
148 Almelec	0.224	0.370	1.749	365	456

Table 7.2.2-2 Electrical Characteristics of Conductors and Cables (30 kV)

Type of Conductor	Line Impedance R1 (ohms/km)	Line Impedance X1 (ohms/km)	Charging Capacity (kVAr/km)	Allowable Current Normal (A)	Allowable Current Abnormal (A)
Underground Cables					
PI 3 x 50 Cu	0.456	0.138	39.393	180	198
PI 3 x 95 Cu	0.228	0.126	52.773	270	297
PI 3 x 120 Cu	0.180	0.120	56.504	315	347
PI 3 x 150 Cu	0.148	0.114	62.154	270	297
PRC-TOR 50 Al	0.756	0.152	28.984	160	195
PRC-TOR 95 Al	0.378	0.138	36.089	230	285
PRC-TOR 150 Al	0.243	0.131	42.060	295	360
PRC-TOR 240 Al	0.148	0.123	49.945	385	485
Conductors					
22 Cu	0.818	0.410	1.598	145	180
38 Cu	0.474	0.390	1.671	200	250
54.6 Almelec	0.604	0.410	1.585	190	238
93.3 Almelec	0.354	0.380	1.695	275	344
148 Almelec	0.224	0.370	1.749	365	456

Table 7.2.2-3 Electrical Characteristics of Conductors (90 kV)

Type of Conductor	Line Impedance R1 (ohms/km)	Line Impedance X1 (ohms/km)	Charging Capacity (kVAr/km)	Allowable Current (A)	Allowable Current (MVA)
Alu-acier					
228 sqmm	0.170	0.38	24	525	81
Almelec					
228 sqmm	0.158	0.40	22	480	75
288 sqmm	0.125	0.39	23	530	86
366 sqmm	0.094	0.39	24	640	100
430 sqmm	0.078	0.38	24	705	110
570 sqmm	0.058	0.37	25	900	

Table 7.2.2-4 Allowable Current of Bus Conductors (MT)

Geometry of Bus Conductors	Sectional Area (sqmm, Cu)	Allowable Current(*) (A)
Trolley - Round bus conductor		
120/10	116	290
80/10	48	170
70/10	38	140
60/10	28	110
Rectangular (width/thickness)		
50/5	250	600
40/5	200	500
30/5	150	400
30/4	120	360
Ring - hollow tube (Outer/inner diameter)		
20/16	113	350
16/12	88	300

(*) : Calculating condition is as follows :
- Temperature rise of bus conductor : 35 ℃
- Ambient temperature : 30 ℃
- No wind

Table 7.2.2-5 Power Supply Radius of Low Tension Distribution Line (B2)

Type and Cross Sectional Area (sqmm)	Impedance		Ampacity		Radius of power supply for 5% voltage drop				
	R1	X1	A	kVA	T = 1.0	T = 0.85	T = 0.75	T = 0.65	T = 0.5
Underground Cable									
(3 x 50 + 1 x 50) Cu	0.479	0.086	150	100	290	340	390	450	580
(3 x 95 + 1 x 50) Cu	0.240	0.085	240	160	330	390	440	510	660
(3 x 150 + 1 x 70) Cu	0.155	0.083	300	200	380	460	510	580	760
(3 x 240 + 1 x 95) Cu	0.096	0.081	400	260	400	470	530	620	800
Overhead Cable (preassembled)									
3 x 70 Al + 1 x 54.6 Almelec	0.55	0.12	180	120	210	250	280	320	420
3 x 35 Al + 1 x 54.6 Almelec	1.10	0.13	120	80	165	195	220	255	330
Overhead Line									
3 x 22 Cu	0.82	0.33	145	95	160	180	200	240	310
3 x 38 Cu	0.47	0.31	200	130	180	200	230	270	350
3 x 74 Cu	0.24	0.29	300	200	190	210	250	290	370

Note : T = Load factor low tension feeders at peak time

Table 7.2.2-6 Load Density For MT/BT Poste Size

Type and Cross Sectional Area (sqmm)	Nominal Capacity of Trans. (kVA)	Load Density (kVA/sqkm) T = 1.0	T = 0.85	T = 0.75	T = 0.65	T = 0.50	Minimum number of feeders per MT/BT poste T = 1.0	T = 0.85	T = 0.75	T = 0.65	T = 0.50
Underground Cable	100	220	150	120	90	60	1	1	1	1	1
	160	350	240	200	150	90	1	1	2	2	2
(3 x 150 + 1 x 50) Cu	250	550	380	300	240	140	2	2	2	2	3
	400	880	600	490	380	220	2	3	3	4	4
	630	1,390	950	770	600	350	4	4	5	5	7
	800	1,760	1,200	980	760	440	4	5	6	7	*8
	1,000	2,200	1,500	1,220	950	560	5	6	7	8	*10
Overhead Cable (preassembled)	100	720	510	400	310	180	1	1	2	2	2
	160	1,160	820	650	500	290	2	2	2	3	3
3 x 70 Al + 1 x 54.6 Almelec	250	1,800	1,280	1,020	780	450	3	3	3	4	5
	400	2,880	2,040	1,620	640	720	4	4	5	6	7
	630	4,540	3,210	2,560	1,960	1,140	6	7	7	*9	*11
	800	5,780	4,080	3,240	2,490	1,440	7	*8	*9	*11	*14
	1,000	7,220	5,100	4,060	3,100	1,800	*9	*10	*12	*13	*17
Overhead Line	100	980	800	600	440	260	1	1	1	2	2
	160	1,570	1,270	960	700	420	2	2	3	3	3
3 x 38 Cu	250	2,460	1,990	1,510	1,090	650	2	3	3	3	4
	400	3,930	3,180	2,410	1,750	1,040	4	4	5	5	6
	630	6,190	5,020	3,790	2,750	1,640	5	6	7	8	*10
	800	7,860	6,370	4,820	3,490	2,080	7	8	*9	*10	*13
	1,000	9,830	7,960	6,020	4,370	2,600	8	*10	*11	*13	*16

Note : a) T = Average load factor of low tension feeders at peak time
b) Load density at the output equivalent to rated capacity of transformer
* Number of excessive feeders

Table 7.2.3-1 Evolution of Load of Injector Station (Grid Station, Distribution Substation)

Grid Substation	Installed Capacity (MVA)	Guaranteed Capacity (MVA)	Year			
			1991 (MVA)	1992-96 (*) (MVA)	1997-2000 (*) (MVA)	2005-05 (*) (MVA)
Bel Air	3 x 10 + 2 x 7.9	36.0	26.7	22.2	22.0	24.6
Hann :	2 x 40 + 1 X 80	64	53.4	62.5 (**)	69	80.9
- Centre Ville	2 x 16.1	16	6.8	7.6	9.6	10.7
- Usine des Eaux	2 x 15	15	10.4	10.1	10.4	11.6
- Universite	2 x 15	15	10.6	9.8	10.6	11.0
Cap des Biches	2 x 33	33	16.8	20.0	23.9	28.9
- Thiaroye	2 x 7.9	7.9	8.4	8.2	7.8	7.0
Total (Bel Air + Hann + Cap des Biches)			96.9	104.7	114.9	134.4

Note : (*) : Modification and reinforcement proposed for 1991 is taken into consideration
(**) : 80 MVA transformer is required after 1996 in Hann Grid substation.

Table 7.2.3-2 Rehabilitation Program of 6.6 kV Distribution Lines (Priority Works 1992)

Substation (Trunk line)	Section		Conductor		Length (m)	Nature of problem
	Ident. No.	Location	Old	New		
Bel Air						
- Yoff	1039	HLM ON13/Douane Boppa	22 sqmm Cu	148 sqmm	500	Bottleneck
	1045	Puits 14/ bassam	22 sqmm Cu	148 sqmm	200	Bottleneck
- Grand dakar	1017	Sicap Rue 10/F. Canadiens	22 sqmm Cu	148 sqmm	100	Bottleneck
	1021	lotissement/baobab O.	22 sqmm Cu	148 sqmm	250	Bottleneck
Centre Ville						
- Credit Foncier	2301	Credit F. / C. Culturel	22 sqmm Cu	148 sqmm	75	Overload
	2302	C. Culturel/ Vox	22 sqmm Cu	148 sqmm	100	Overload
Usine des Eaux						
- Puits 12	4609	Puits 12/ Bourguiba	38 sqmm Cu	148 sqmm	400	Bottleneck
	4612	Imas/ Gras et Drieux	22 sqmm Cu	148 sqmm	75	Bottleneck
	4613	Gras et Drieux/ HL MON 11	22 sqmm Cu	148 sqmm	300	Bottleneck
Total					2,000	

Table 7.2.3-3 Changeover Program of 6.6 kV Load to 30 kV Network

	Load to be changed to 30 kV (kVA)			
	Priority Works 1992	Short term 1993-1996	Medium term 1997-2000	Long term 2001-2005
Bel Air				
Bel Air				
- Grand Dakar	1,000	1,200	1,200	800
- Yoff		1,000	500	
- Dispensaire		500	1,000	1,300
- Concession			500	
Total Bel Air	1,000	2,700	3,700	2,100
Hann				
Universite				
- Fann		700	300	300
- Mermoz			400	400
Usine des Eaux				
- Puits 12		1,000	300	500
- Dieupeul Ecole		500		
- Sibras			400	
Aeroport Yoff				
- Air Senegal		1,000	500	1,450
- Batterie Yoff	500			450
Total Hann	500	3,200	1,900	3,400
Cap des Biches				
Thiaroye				
- Route de Rufisque	300	500	600	1,200
- Dagoudane Pikine		600	400	300
- Yeumbeul		800	500	800
- Labo Pecherie		500	1,000	2,000
Total Cap des Biches	300	2,400	2,500	4,300

Table 7.2.3-4 Summary of Rehabilitation Program of 6.6 kV Distribution Line

Trunk Line from Substation	Priority Works 1992 (m)	Short term 1993-1996 (m)	Medium term 1997-2000 (m)	Long term 2001-2005 (m)
Bel-Air	1,050	550	370	500
Centetre Ville	175	100	-	-
Universite	-	700	-	-
Usine des Eaux	775	-	-	-
Aeroport	-	1,250	1,840	2,950
Thiaroye	-	650	-	-
Total Line Length of 6.6 kV line to be rehabilitated	2,000	3,250	2,210	3,450

Table 7.2.3-5 Rehabilitation Program of 6.6 kV Distribution Lines (Short Term 1993 -1996)

Substation (Trunk line)	Section		Conductor		Length (m)	Nature of problem
	Ident. No.	Location	Old	New		
Bel Air						
- Concession	1098	R. Brasseries/J. Mermoz	50/10	148 sqmm	100	Overload
	1101	J. Mermoz/Saviem	50/10	148 sqmm	100	Overload
	1102	Saviem/SPAC	38 Cu	148 sqmm	150	Bottleneck
- Dispensaire	1133	Livraison/Huile Cayor	22 Cu	148 sqmm	200	Overload
Centre Ville						
- Foncier Zola	2406	Consulat/Anse Bernard	22 Cu	150 sqmmal(*)	100	Bottleneck
Universite						
- Fann	3322	Fann Nord/R. Corniche	PILC 25 (*)	93.3 sqmm(*)	700	Bottleneck
Aeroport						
- Air Senegal	6301	Terre Nord/Forage	22 Cu	148 sqmm	1250	Bottleneck
Thiaroye						
- Route de Rufisque	5101	PTT/Thiaroye M.	38 Cu	148 sqmm	500	Overload
	5102	PTT/Touba	38 Cu	148 sqmm	100	Overload
	5103	Embranchement Touba	38 Cu	148 sqmm	50	Overload
Total					3,250	

Note : (*) : Underground cable

Table 7.2.3-6 Rehabilitation Program of 6.6 kV Distribution Lines (Medium Term 1997 -2000)

Substation (Trunk line)	Section		Conductor		Length (m)	Nature of problem
	Ident. No.	Location	Old	New		
Bel Air						
- Dispensaire	1194	Mole VIII/C.S.L.	22 sqmm Cu	148 sqmm	50	Bottleneck
	1196	C.S.L./Shell Port	22 sqmm Cu	148 sqmm	170	Bottleneck
	1198	Shell Port/Shell Mole VIII	PILC 25(*)	148 sqmm	150	Overload
Areport Yoff						
- Batterie Yoff	6114	Casino/Hotel N'Gor	25 sqmm Cu	148 sqmm	130	Overload
	6115	Hotel N'Gor/Livraison	25 sqmm Cu	148 sqmm	460	Overload
	6116	Livraison/Kebe	25 sqmm Cu	148 sqmm	350	Overload
	6117	Kebe/A. Almadies	25 sqmm Cu	148 sqmm	900	Overload
Total					2,210	

Note : (*) : Underground cable

Table 7.2.3-7 Rehabilitation Program of 6.6 kV Distribution Lines (Long Term 2001 -2005)

Substation (Trunk line)	Ident. No.	Section Location	Conductor		Length (m)	Nature of problem
			Old	New		
Bel Air						
- Dispensaire	1185	Mole V/Taiba	38 sqmm Cu	148 sqmm	275	Bottleneck
	1188	Taiba/Mole VIII	38 sqmm Cu	148 sqmm	200	Bottleneck
	1193	Mole VIII/CSL	38 sqmm Cu	148 sqmm	25	Bottleneck
Areport Yoff						
- Batterie Yoff	6100	Sous-Station/Yoff P.	95 sqmm Cu(*)	148 sqmm (*)	720	Section overload
	6101	Yoff P./Commissariat	95 sqmm Cu(*)	148 sqmm (*)	110	Section overload
	6102	Yoff P./Batterie	95 sqmm Cu(*)	148 sqmm (*)	600	Section overload
	6110	Batterie/Virage	95 sqmm Cu(*)	148 sqmm (*)	430	Section overload
	6111	Virage/Secteur Hotel	50 sqmm Cu(*)	148 sqmm (*)	950	Section overload
	6112	Secteur Hotel/Casino	50 sqmm Cu(*)	148 sqmm (*)	90	Section overload
Total					3,450	

Note : (*) : Underground cable

Table 7.2.3-8 Summary of Extension Program of Medium Voltage Distribution Lines

	Priority Works 1992	Short term 1993-1996	Medium term 1997-2000	Long term 2001-2005
Length of Extension (m)				
- Normal at 6.6 kV : A	-	3,000	1,000	800
S	-	3,000	1,000	
- Normal at 30 kV : A	-	2,000	3,000	1,300
S	-	4,000	5,000	2,100
- Changeover to 30 kV : A	500	3,000	5,000	
S	1,000	2,500	2,000	
	1,500	17,500	17,000	
30kV/BT Transformer (kVA)	1,800	8,300	9,800	300 400
6.6kV/BT Transformer (kVA)	-	2,800	4,200	500
Total	1,800	11,100	14,000	

Note : A : Overhead line
S : Underground cable

Table 7.3.2-1 Creepage Distance

POLLUTION LEVEL	EXAMPLES OF TYPICAL ENVIRONMENTS	MINIMUM SPECIFIC NOMINAL CREEPAGE DISTANCE between phase and ground mm/phase-to-phase kV (highest voltage)
I - Light	- Areas without industries and with low intensity of houses equipped with heating plants. - Areas with low density of industries or houses but subjected to frequent winds and/or rainfalls. - Agricultural areas (1). - Mountainous areas. All these areas must be situated far from the sea (10 to 20 km) and must not in any case be exposed to winds directly from the sea (2).	16
II - Medium	- Areas with industries not producing particularly polluting smokes and/or with average density of houses equipped with heating plants. - Areas with high density of houses and/or industries but subjected to frequent clean winds and/or rainfalls. - Areas exposed to wind from the sea but not too close to the coast (at least a few kilometers) (2).	20
III - Heavy	- Areas with high density of industries and suburbs of large cities with high density of heating plants producing pollution. - Areas close to sea or in any case exposed to relatively strong winds from the sea (2).	25
IV - Very heavy	- Areas generally of moderate extension, subjected to conductive dusts and to industrial smokes producing particularly thick conductive deposits. - Areas generally of moderate extension, very close to the coast and exposed to sea-sprays or to very strong and polluting winds from the sea. - Desert areas, characterized by no rain for long periods, exposed to strong winds carrying sand and salt, and subjected to regular condensation.	31

IEC-815 (1986) Guide for the selection of insulators in respect of polluted conditions.

(1) Use of fertilizers by spraying can lead to a higher pollution level due to dispersal by wind.

(2) Distance from sea coast depend on the topography of the coastal areas and on the extreme wind conditions.

Note 1: In very clean areas, specific creepage distances lower than 16 mm/kV can be chosen depending on service experience.

Note 2: In case of exceptional pollution severity a specific creepage distance of 31 mm/kV could not be adequate.

Table 7.4.1-1 Specification of Existing Circuit Breakers (1/4)

1. Centre-Ville (1/2)

Name of feeder	Tr. No. 1 & 2	Tr. No. 1 & 2	BLANCHOT L.SOW	HOTEL NINA
Bus voltage	30 kV	6.6 kV	6.6 kV	6.6 kV
Kind	OCB	SF6	SF6	OCB
a. Manufacturing year	-	Oct., 1980	Nov., 1982	-
b. Manufacturer	VERVIERS EIB	Melin Gerin	Melin Gerin	VERVIERS EIB
	Brussels			Brusels
c. Type		FC3250	F84-80	A20S/300/6
d. Un (kV)	30/36	24	24	20/23
e. Isym (kA)	6.7/5.6	25	8	8.7/7.5
f. Iasym (kA)	7.6/6.9			9.7/8.4
g. Ie (kA)	17/14	63	50	22/19
h. In (A)	630	1,250	400	630
i. G (kg)	175	175		90
j. Pn (MVA)	350			300
k. Itherm (kA)	20			20
l. Idyn (kA)	50		50	50
m. f (Hz)	50			50
n. fo (kHz)	9.6			4.6
o. K	1.4			1.4
p. Cycle nominal	0-3min-CO-3min-CO	0-3min-CO-3min-CO	0-3min-CO-3min-CO	0-3min-CO-3min-CO

1. Centre-Ville (2/2)

Name of feeder	RESIDENCE CAP-VERT	FONCIER ZOLA	CREDITL FONCIER	MOHAMED V CARNOT
Bus voltage	6.6 kV	6.6 kV	6.6 kV	6.6 kV
Kind	OCB	OCB	OCB	OCB
a. Manufacturing year	-	-	-	-
b. Manufacturer	VERVIERS EIB	VERVIERS EIB	VERVIERS EIB	VERVIERS EIB
	Brusels	Brusels	Brusels	Brusels
c. Type	A20S/300/6	A20S/300/6	A20S/300/6	A20S/300/6
d. Un (kV)	20/23	20/23	20/23	20/23
e. Isym (kA)	8.7/7.5	8.7/7.5	8.7/7.5	8.7/7.5
f. Iasym (kA)	9.7/8.4	9.7/8.4	9.7/8.4	9.7/8.4
g. Ie (kA)	22/19	22/19	22/19	22/19
h. In (A)	630	630	630	630
i. G (kg)	90	90	90	90
j. Pn (MVA)	300	300	300	300
k. Itherm (kA)	20	20	20	20
l. Idyn (kA)	50	50	50	50
m. f (Hz)	50	50	50	50
n. fo (kHz)	4.6	4.6	4.6	4.6
o. K	1.4	1.4	1.4	1.4
p. Cycle nominal	0-3min-CO-3min-CO	0-3min-CO-3min-CO	0-3min-CO-3min-CO	0-3min-CO-3min-CO

Table 7.4.1-1 Specification of Existing Circuit Breakers (2/4)

2. Universite (1/2)

Name of feeder	Tr. No. 1 & 2	Tr. No. 1 & 2	IUT	FANN
Bus voltage	30 kV	6.6 kV	6.6 kV	6.6 kV
Kind	OCB	SF6	SF6	OCB
a. Manufacturing year	-	Oct., 1980	-	-
b. Manufacturer	VERVIERS EIB	Melin Gerin	ALSTHOM	VERVIERS EIB
	Brussels			Brusels
c. Type	A30/350/6	FC 3250	BLRM	A205/300/6
d. Un (kV)	30/36	24	23	20/23
e. Isym (kA)	6.7/5.6	25	12.5	8.7/7.5
f. Iasym (kA)	7.6/6.3			9.7/8.4
g. Ie (kA)	17/14	63	31.2	22/19
h. In (A)	630	1,250	400	630
i. G (kg)	175	175		90
j. Pn (MVA)	350			300
k. Itherm (kA)	20			20
l. Idyn (kA)	50			50
m. f (Hz)	50		50	50
n. fo (kHz)	3.6			4.6
o. K	1.4			1.4
p. Cycle nominal	0-3min-CO-3min-CO	0-3min-CO-3min-CO		0-3min-CO-3min-CO

2. Universite (2/2)

Name of feeder	MERMOZ	POINTE E	SECOURS MERMOZ	ABASS N'DAO
Bus voltage	6.6 kV	6.6 kV	6.6 kV	6.6 kV
Kind	OCB	OCB	OCB	OCB
a. Manufacturing year	-	1977	1977	-
b. Manufacturer	VERVIERS EIB	DELLE ALSTHOM	DELLE ALSTHOM	VERVIERS EIB
	Brussels			Brusels
c. Type	A205/300/6	HL 620	HL 620	A205/300/6
d. Un (kV)	20/23	24	24	20/23
e. Isym (kA)	8.7/7.5	7.2/6	7.2/6	8.7/7.5
f. Iasym (kA)	9.7/8.4	7.9/6.6	7.9/6.6	9.7/8.4
g. Ie (kA)	22/19	18/15	18/15	22/19
h. In (A)	630	630	630	630
i. G (kg)	90			90
j. Pn (MVA)	300			300
k. Itherm (kA)	20			20
l. Idyn (kA)	50			50
m. f (Hz)	50	50	50	50
n. fo (kHz)	4.6			4.6
o. K	1.4			1.4
p. Cycle nominal	0-3min-CO-3min-CO	0-3min-CO-3min-CO	0-3min-CO-3min-CO	0-3min-CO-3min-CO

Table 7.4.1-1 Specification of Existing Circuit Breakers (3/4)

3. AEROPORT YOFF (1/2)

Name of feeder	Tr. No. 1 & 2	Tr. No. 1	Tr. No. 2	TERME SUD
Bus voltage	30 kV	6.6 kV	6.6 kV	6.6 kV
Kind	OCB	OCB	OCB	SF6
a. Manufacturing year	-	-	-	-
b. Manufacturer	VERVIERS EIB Brussels	VERVIERS EIB Brussels	VERVIERS EIB Brussels	ALSTHOM
c. Type	A30/350/6	A205/300/6	A205/300/6	BLRM
d. Un (kV)	30/36	20/23	20/23	23
e. Isym (kA)	6.7/5.6	8.7/7.5	8.7/7.5	12.5
f. Iasym (kA)	7.1/6.3	9.7/8.4	9.7/8.4	
g. Ie (kA)	17/14	22/19	22/19	31.2
h. In (A)	630	630	630	400
i. G (kg)	175	90	90	
j. Pn (MVA)	350	360	360	
k. Itherm (kA)	20	20	20	
l. Idyn (kA)	50	50	50	
m. f (Hz)	50	50	50	50
n. fo (kHz)	3.6	4.6	4.6	
o. K	1.4	1.4	1.4	
p. Cycle nominal	0-3min-CO-3min-CO	0-3min-CO-3min-CO	0-3min-CO-3min-CO	

3. AEROPORT YOFF (2/2)

Name of feeder	AIR SENEGAL	BATTERIE YOFF		
Bus voltage	6.6 kV	6.6 kV		
Kind	SF6	OCB		
a. Manufacturing year	Nov. '82	-		
b. Manufacturer	Melin Gerin	VERVIERS EIB Brusels		
c. Type	FB.480	A/205/300/6		
d. Un (kV)	24	20/23		
e. Isym (kA)	8	8.7/7.5		
f. Iasym (kA)		9.7/8.4		
g. Ie (kA)	50	22/19		
h. In (A)	400	630		
i. G (kg)		90		
j. Pn (MVA)		360		
k. Itherm (kA)		20		
l. Idyn (kA)		50		
m. f (Hz)	50	50		
n. fo (kHz)		4.6		
o. K		1.4		
p. Cycle nominal	0-3min-CO-3min-CO	0-3min-CO-3min-CO		

Table 7.4.1-1 Specification of Existing Circuit Breakers (4/4)

4. Thiaroye (1/2)

Name of feeder	Tr. No. 1 & 2	Tr. No. 1 & 2	COUPURE TRASOCEANIQUE	LABO PECHERIE
Bus voltage	30 kV	6.6 kV	30 kV	6.6 kV
Kind	SF6	MBB	SF6	MBB
a. Manufacturing year	Mar '77	Apr '77	Feb '78	Apr '77
b. Manufacturer	Melin Gerin	Melin Gerin	Melin Gerin	Melin Gerin
c. Type	FB4-80	DIS 1T 2.25B	FB4-80	DIS 1T 2.25B
d. Un (kV)	36	24	36	24
e. Isym (kA)	8	7.2	8	7.2
f. Iasym (kA)				
g. Ie (kA)	50	75	50	75
h. In (A)	400	1,250	400	630
i. G (kg)				
j. Pn (MVA)				
k. Itherm (kA)				
l. Idyn (kA)				
m. f (Hz)	50	50	50	50
n. fo (kHz)				
o. K				
p. Cycle nominal	0-3min-CO-3min-CO	C	0-3min-CO-3min-CO	C

4. Thiaroye (2/2)

Name of feeder	YEUMBEUL	ICOTAF	ROUTE DE RUFISQUE	DAGOUDANE PIKINE
Bus voltage	6.6 kV	6.6 kV	6.6 kV	6.6 kV
Kind	MBB	OCB	SF6	OCB
a. Manufacturing year	Apr '77			
b. Manufacturer	Melin Gerin	DELLE	ALSTHOM	DELLE ALSTHOM
c. Type	DIS 1T 2.25B	HG3/4	BLRM	HL 620
d. Un (kV)	24	7.2	23	24
e. Isym (kA)	7.2	13.12	12.5	12.5
f. Iasym (kA)				18.8
g. Ie (kA)	75	32.8	31.2	31.5
h. In (A)	630	800	400	400
i. G (kg)				
j. Pn (MVA)				
k. Itherm (kA)				
l. Idyn (kA)				
m. f (Hz)	50	50	50	50
n. fo (kHz)				
o. K				
p. Cycle nominal	C			0-3min-CO-3min-CO

Table 7.4.2-1 Maximum Load of Substations and Feeders (6.6 kV)

	1992	1993	1994
	Max. (kW)	Max. (kW)	Max. (kW)
Centre Ville	9,680	9,880	9,200
Hotel Nina	1,420	1,860	2,240
Residence Cap-Vert	1,680	1,780	1,980
Foncier Zola	2,540	2,640	2,900
Credit Foncier	1,680	740	1,340
Mohamad V carnot	3,180	2,060	2,920
Blanchot Lamine Sow	1,760	1,960	1,660
Universite	8,770	10,560	9,600
Hann	2,780	2,180	2,280
Mermoz	2,420	1,560	1,820
pointe E	3,000	3,040	2,440
Mermoz Secours	2,700	1,900	2,360
Abass Ndao	2,300	2,980	2,700
IUT	1,940	1,840	2,040
Aeroport Yoff	6,800	6,760	8,700
Batterie Yoff	2,440	3,440	2,660
Air Senegal	2,040	1,900	2,360
Terme Sud	3,240	3,840	3,340
Usine des Eaux	10,880	11,900	11,970
Front de Terre	3,920	3,920	3,960
Sibras	2,240	3,320	2,580
Hann (6.6kV)	1,460	1,900	2,040
Puits 12	4,240	3,920	3,680
Dieupeul Ecole	2,880	2,420	3,800
Sodida	2,120	1,720	2,240
Thiaroye	8,870	8,990	11,200
Labo Pecherie	2,500	1,860	1,530
Yeumbeul	1,800	1,920	1,860
Rte de Rufisque	2,600	2,580	3,600
Dagoudane Pikine	2,120	2,920	3,100
Icotaf	2,380	2,560	3,060
Bel-Air	22,660	22,740	20,840
Arsenal	2,510	2,290	1,880
Elmaf Fumoa	3,700	2,500	2,990
Port-Sud	2,300	1,500	1,650
Dispensaire	4,430	4,120	5,620
Dakar-Est	2,650	2,770	2,510
Yoff	2,560	4,030	3,450
Grand Dakar	3,030	2,680	2,680
Grande Voirie	2,500	2,530	2,690
Secours Tolbiac	3,140	4,100	3,380
Soto	2,120	2,290	2,900
Sileye Guisse	2,640	2,480	1,480
Medina	2,700	3,210	3,020
Concession	3,140	2,590	3,330

Table 7.4.2-2 Transformer Capacity of Existing Postes (6.6 kV/BT) (1/2)

Name of Distribution substation	Feeder name	Name of poste	Owned by	Tr. capacity (kVA)
Bel-Air	Dispensaire	Mole V	SENELEC	250
		Taiba	Private	600
		Stokage Huile	Private	100
		Mole VIII	SENELEC	250
		Saset	Private	160
		Dsha	Private	315
		BP	Private	Note 1
		C.S. Lubrifiants	Private	Note 1
		Shell Port	Private	Note 1
		Shell Mole VII	Private	Note 1
		DAPT	Common	Note 1
			Sub-total	1,675
Universite	Fann	Fann Nord	Private	250
		Fann Rue 1	SENELEC	250
			Sub-total	500
Aeroport Yoff	Batterie Yoff	Almadies	SENELEC	135
		Vivier Almadies	Private	63
		ABTV	Private	135
		Pointe de Almadies	SENELEC	135
			Sub-total	468
Thiaroye	Rte de Rufisque	M'Bao	SENELEC	100
		Petit M'Bao	SENELEC	160
		GNA	Private	40
		km20 M'Bao Gare	SENELEC	100
		Complexe Avicole de M'	Private	250
		Centre Pie XII	Private	25
		M'Bao Verger	Private	160
		Grand M'Bao	SENELEC	250
		Institut Bilique	Private	50
		Ainoumadi 1	SENELEC	160
		Ainoumadi 2	SENELEC	160
		Ainoumadi 3	SENELEC	250
		Sedima	Private	160
		Keur Massar	SENELEC	160
		Verger Keur Masar	Private	160
		H61 Niacourab	SENELEC	100
			Sub-total	2,285
	Yeumbeul	Yeumbeul Ben Baraque	SENELEC	250
		Yeumbeul Marche	SENELEC	160
		Yeumbeul Marine	SENELEC	100
		H61 Boune 1	Private	160
		Boune 2	Private	160
		Hafia	Private	250
			Sub-total	1,080

Note 1 : to be cinfirmed.

Table 7.4.2-2 Transformer Capacity of Existing Postes (6.6 kV/BT) (2/2)

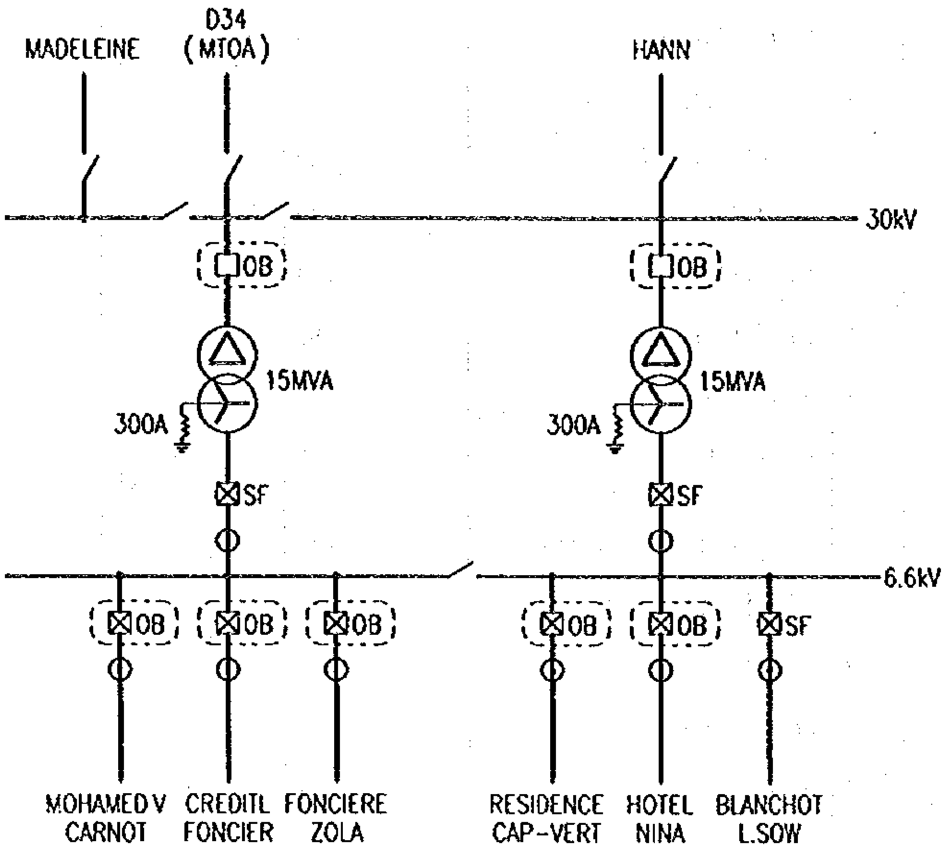
Name of Distribution substation	Feeder name	Name of poste	Owned by	Tr. capacity (kVA)
Thiaroye	Dagoudane Pikine	Dagoudane Sane	SENELEC	160
		Dagoudane Sane II	SENELEC	160
		Guinaw Rail	Private	100
		Guinaw Rail I	Private	100
		Guinaw Rail II	Private	160
		Dag. Alkarim	SENELEC	250
		Dag. Marche	SENELEC	250
		Dispensaire Dominique	Common	160
			Sub-total	1,340
	Labo Pecherie	SSFD	Private	250
		DIPROM	Private	100
		Guirs et Peaux	Private	250
		Socida	Private	160
		Neptune Fishing	Private	160
		km 9	SENELEC	160
		Nehmer	Private	63
		Batisse H61	Private	100
		Areski	Private	160
		Senemeca DP	Private	160
		Marchand	Private	100
		Hann Montagne	Private	100
			Sub-total	1,763
		Total of Thiaroye		6,468

Table 7.4.3-1 Housing Site Under Developing in Dakar Area

No.	Location	Surface Area (ha)	Type of House	No. of Houses/ha	Total No. of Houses
1	Pointe Almadie	200	Exclusive residential	20	4,000
2	Sotrac Pyrotechnie	20	- " -	20	400
3	Nord Liberte 6	40	- " -	20	800
4	Sud Foire	40	- " -	20	800
5	Nord Foire	200	- " -	20	4,000
6	Ouest Foire	50	- " -	25	1,250
7	Grand Yoff	95	- " -	30	2,850
8	Patte D'Oie	198	Medium-class residential	30	5,940
	Total Dakar Ville	843			20,040
1	Golf Nord	70	Economical residential	40	2,800
2	Golf Nord Est	80	- " -	40	3,200
3	Keur Massar	53	- " -	40	2,120
4	Malika	400	Residential	40	16,000
5	Mbao Gare	500	- " -	40	20,000
6	Rufisque Ouest	80	- " -	40	3,200
7	Rufisque Nord	70	- " -	40	2,800
8	Camp Marchand	40	- " -	40	1,600
9	Dalifort	150	- " -	40	6,000
10	Mbao Boun	30	- " -	40	1,200
	Total Pikine - Rufisque	1,473			58,920
	Grand Total	2,316			78,960

Note : Number of houses per hectare and total number of houses are estimated value.

Poste 30/6.6kV Centre Ville



(dashed box)	CB's to be replaced
(switch symbol)	Disconnecting Switch
□	Circuit Breaker (Manual Control)
⊠	Circuit Breaker (Tele-Control)
SF	SF6
OB	OCB
MB	MBB
(two circles)	Transformer
(line with circle)	CT

Fig.7.4.1-1 Circuit Breakers to be Replaced (1/4)

Poste 30/6.6kV Université

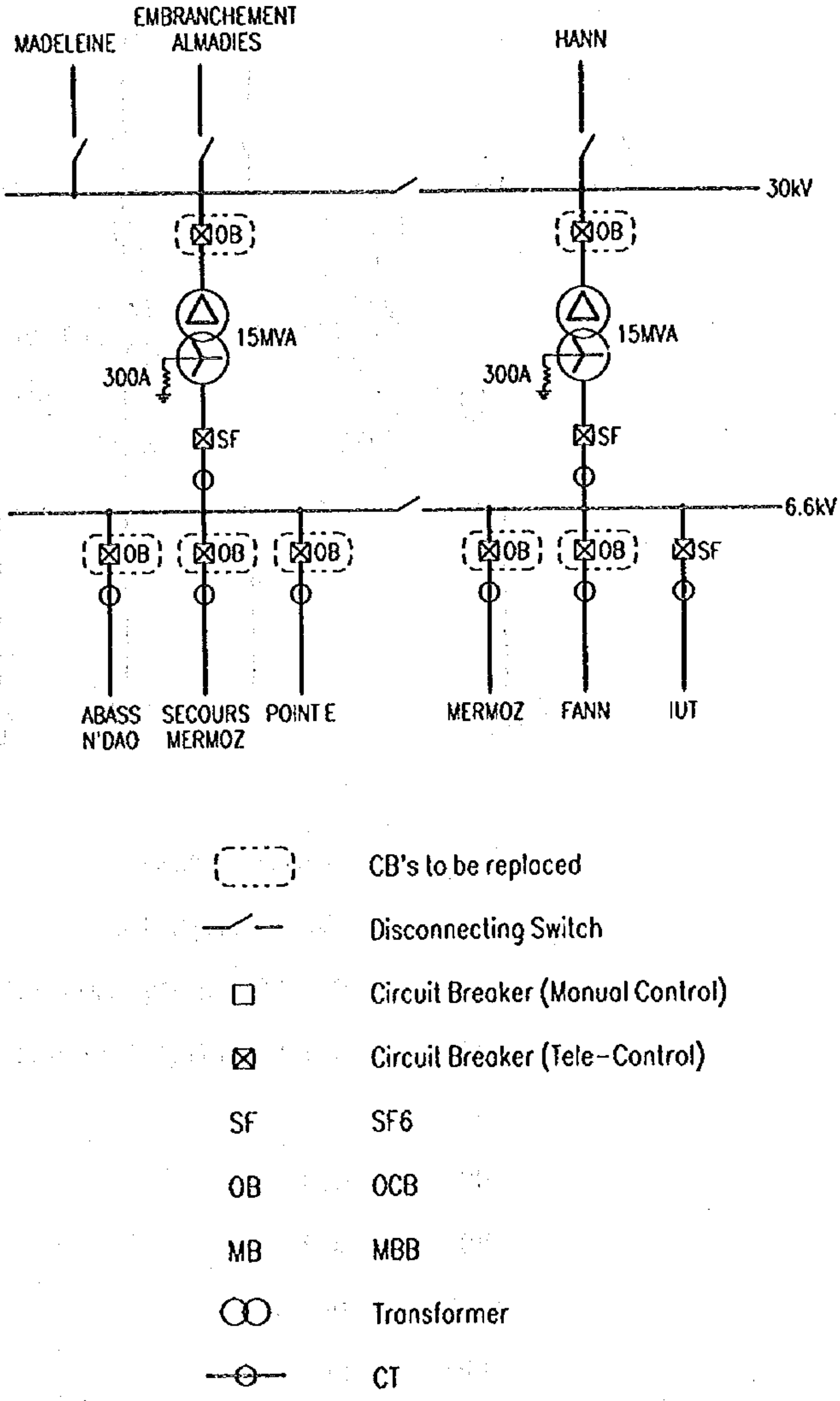
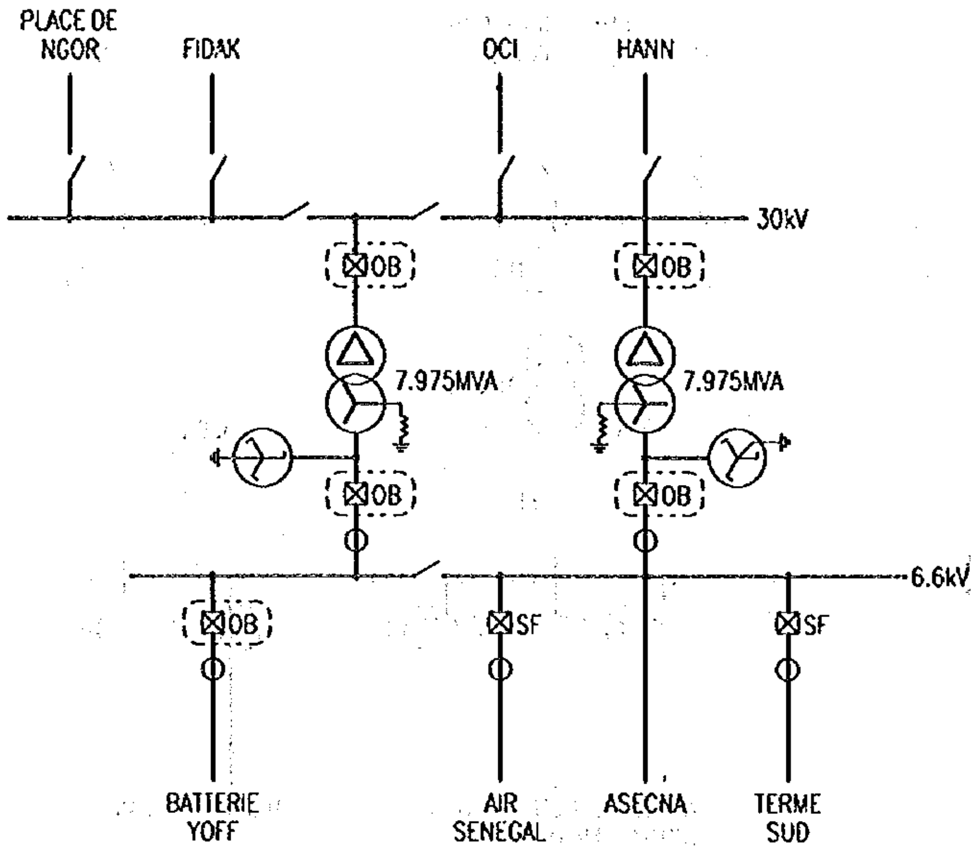


Fig.7.4.1-1 Circuit Breakers to be Replaced (2/4)

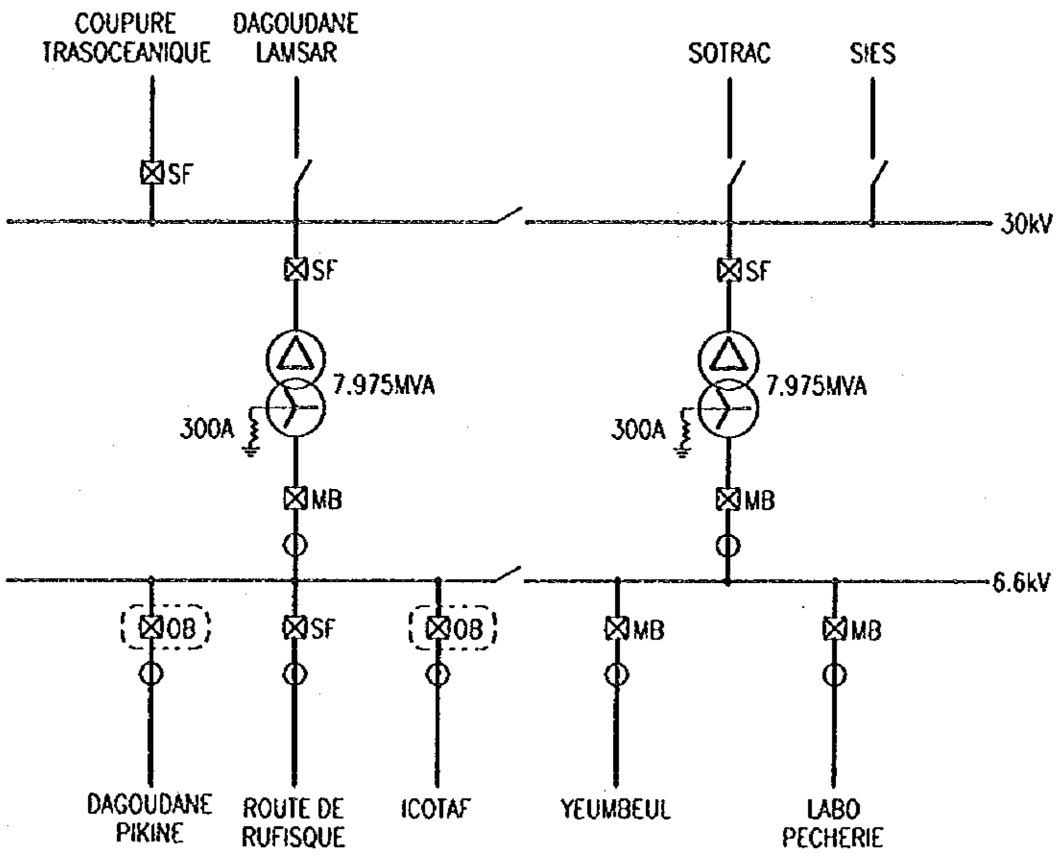
Poste 30/6.6kV Aéroport Yoff



(dashed box)	CB's to be replaced
(switch symbol)	Disconnecting Switch
☐	Circuit Breaker (Manual Control)
⊠	Circuit Breaker (Tele-Control)
SF	SF6
OB	OCB
MB	MBB
(two circles)	Transformer
(circle on line)	CT

Fig.7.4.1-1 Circuit Breakers to be Replaced (3/4)

Poste 30/6.6kV Thiaroye



(dashed box)	CB's to be replaced
—/—	Disconnecting Switch
□	Circuit Breaker (Manual Control)
⊠	Circuit Breaker (Tele-Control)
SF	SF6
OB	OCB
MB	MBB
OO	Transformer
—⊖—	CT

Fig.7.4.1-1 Circuit Breakers to be Replaced (4/4)

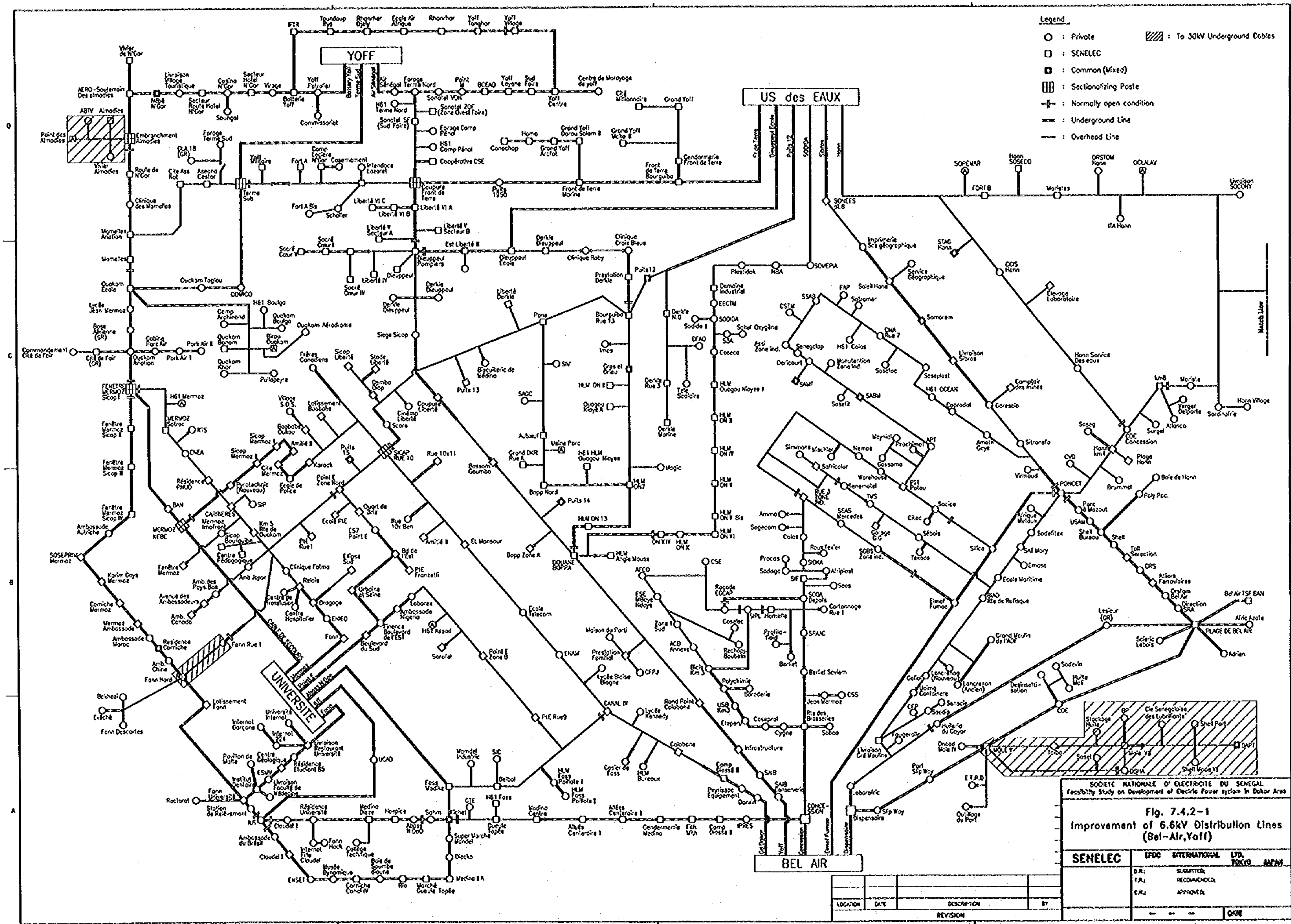
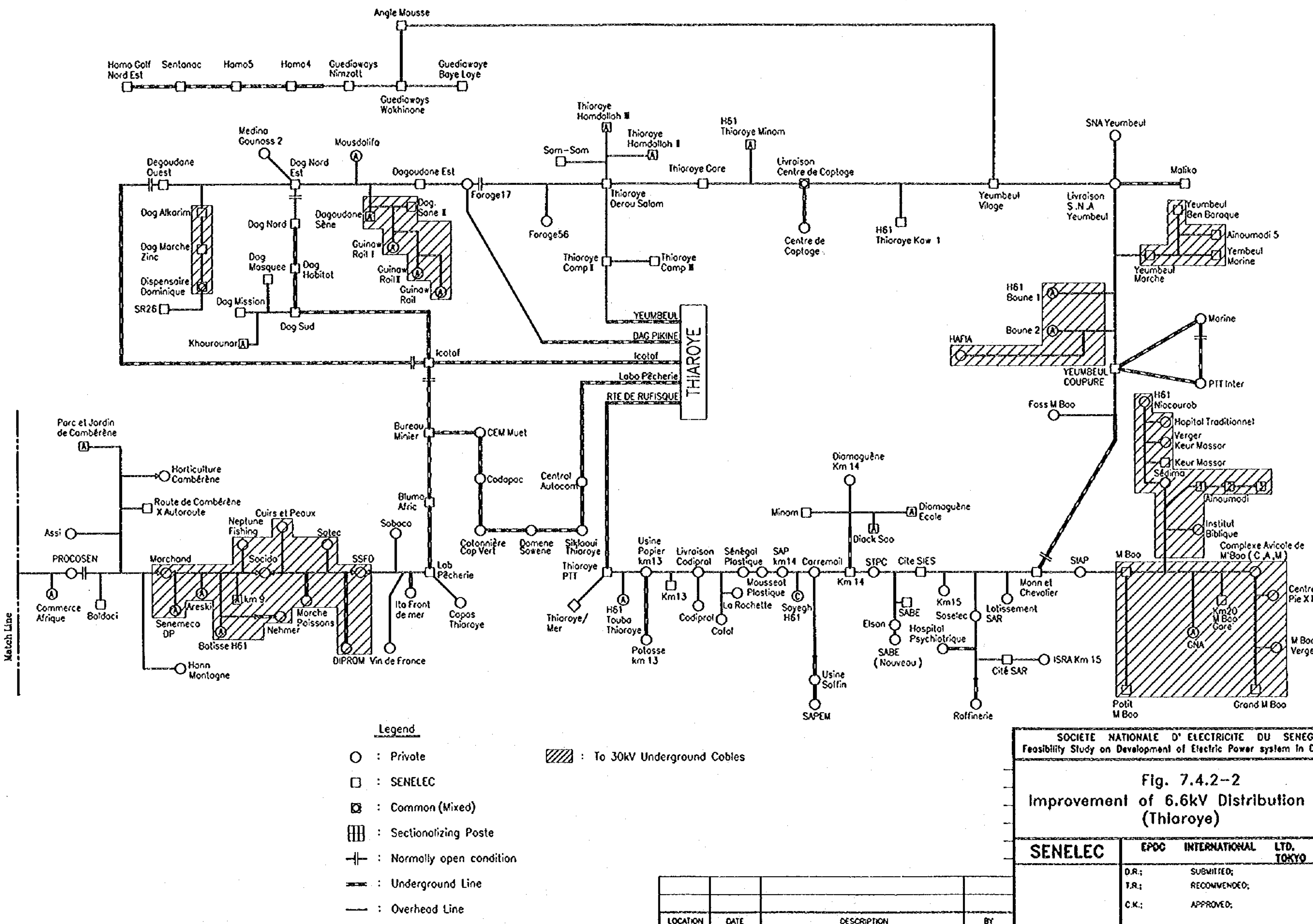


Fig. 7.4.2-1 Improvement of 6.6kV Distribution Lines (Bel-Air, Yoff)



LOCATION	DATE	DESCRIPTION	BY
		REVISION	

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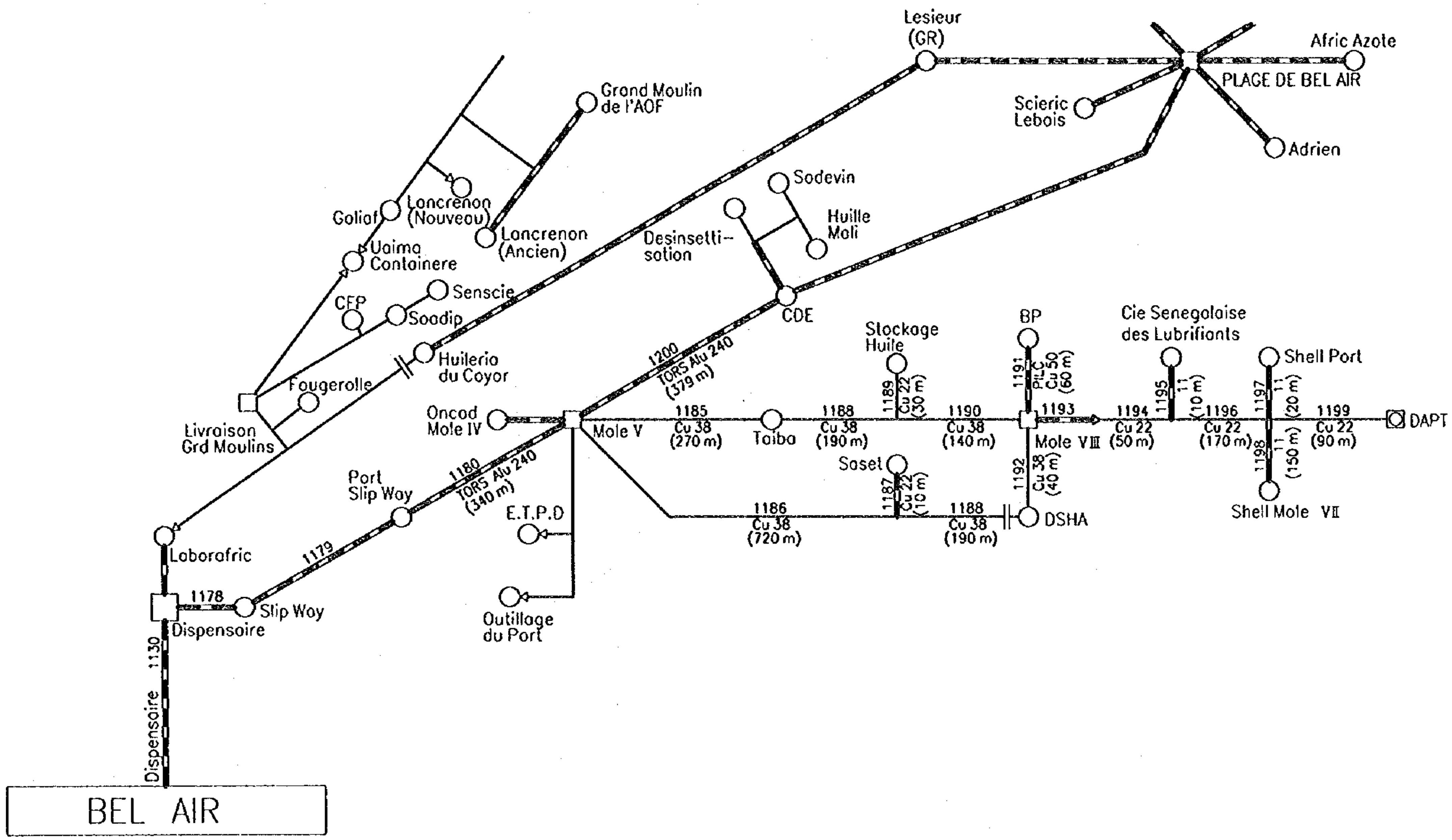
Fig. 7.4.2-2
Improvement of 6.6kV Distribution Lines (Thiaroye)

SENELEC | EPDC INTERNATIONAL LTD. TOKYO JAPAN

D.R.: SUBMITTED:
T.R.: RECOMMENDED:
C.K.: APPROVED:

DATE



Legend

- ○ : Private
- □ : SENELEC
- ⊡ : Common (Mixed)
- ▦ : Sectionalizing Poste
- ⊣⊢ : Normally open condition
- ▬ : Underground Line
- — : Overhead Line

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Fig. 7.4.2-3 Existing 6.6kV Lines to be improved (1/6)

Bel Air : Dispensaire Feeder

SENELEC	EPDC INTERNATIONAL LTD. TOKYO JAPAN
	D.R.: SUBMITTED:
	T.R.: RECOMMENDED:
	C.K.: APPROVED:
	— — — DATE

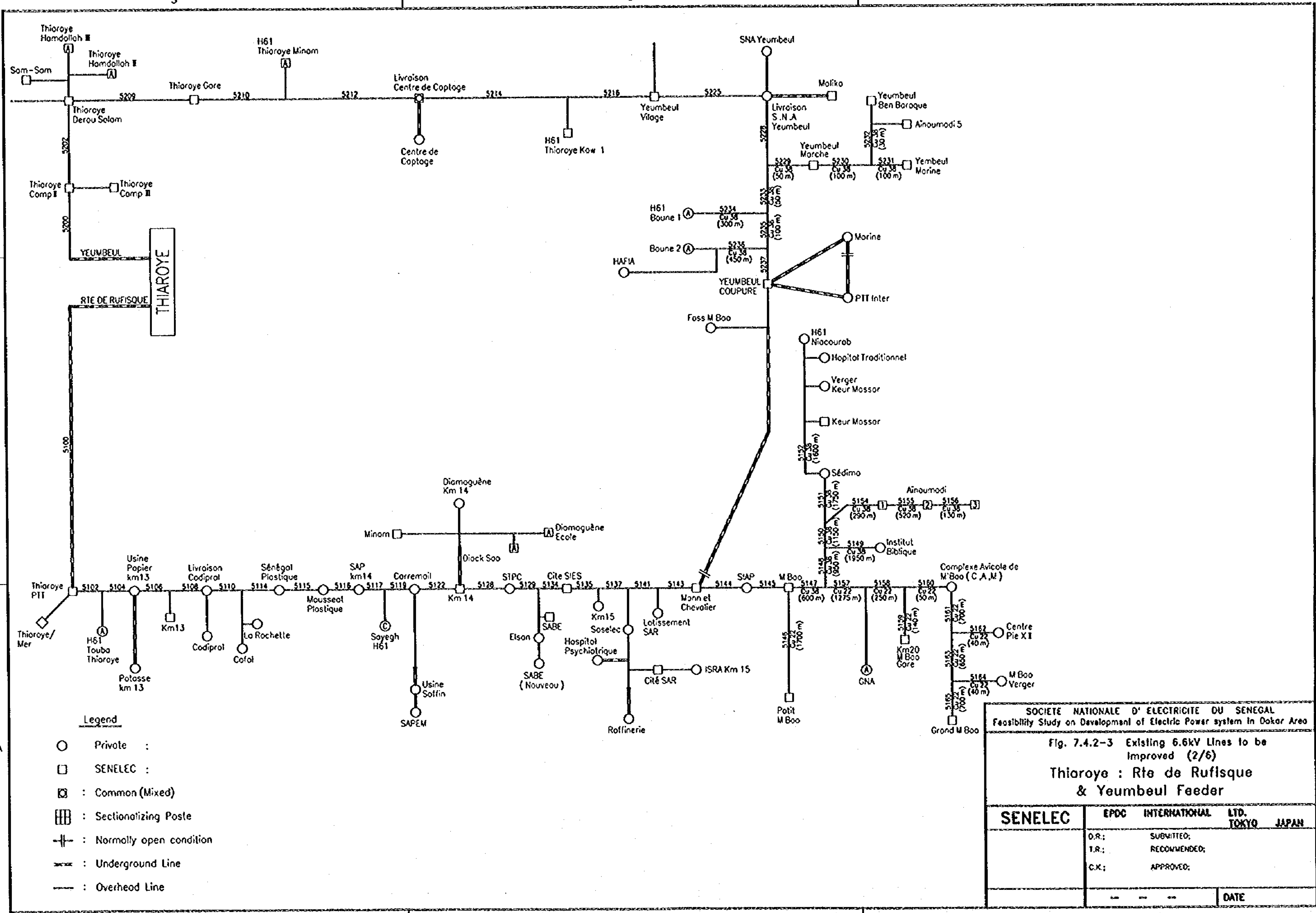

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Fig. 7.4.2-3 Existing 6.6kV Lines to be Improved (2/6)

Thiaroye : Rte de Rufisque & Yeumbeul Feeder

SENELEC	EPDC INTERNATIONAL LTD. TOKYO JAPAN
	D.R.: SUBMITTED:
	T.R.: RECOMMENDED:
	C.K.: APPROVED:
	— — — DATE

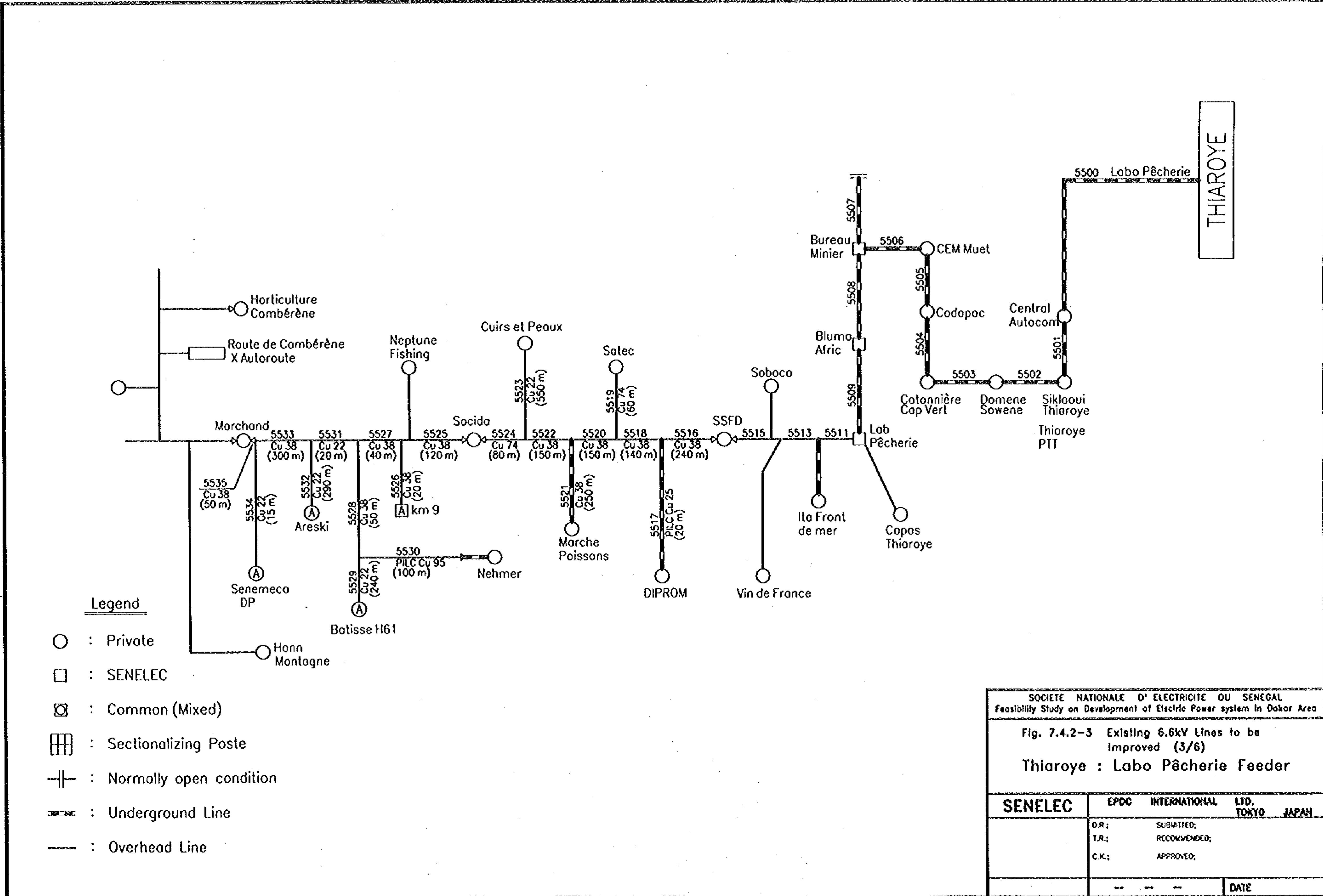

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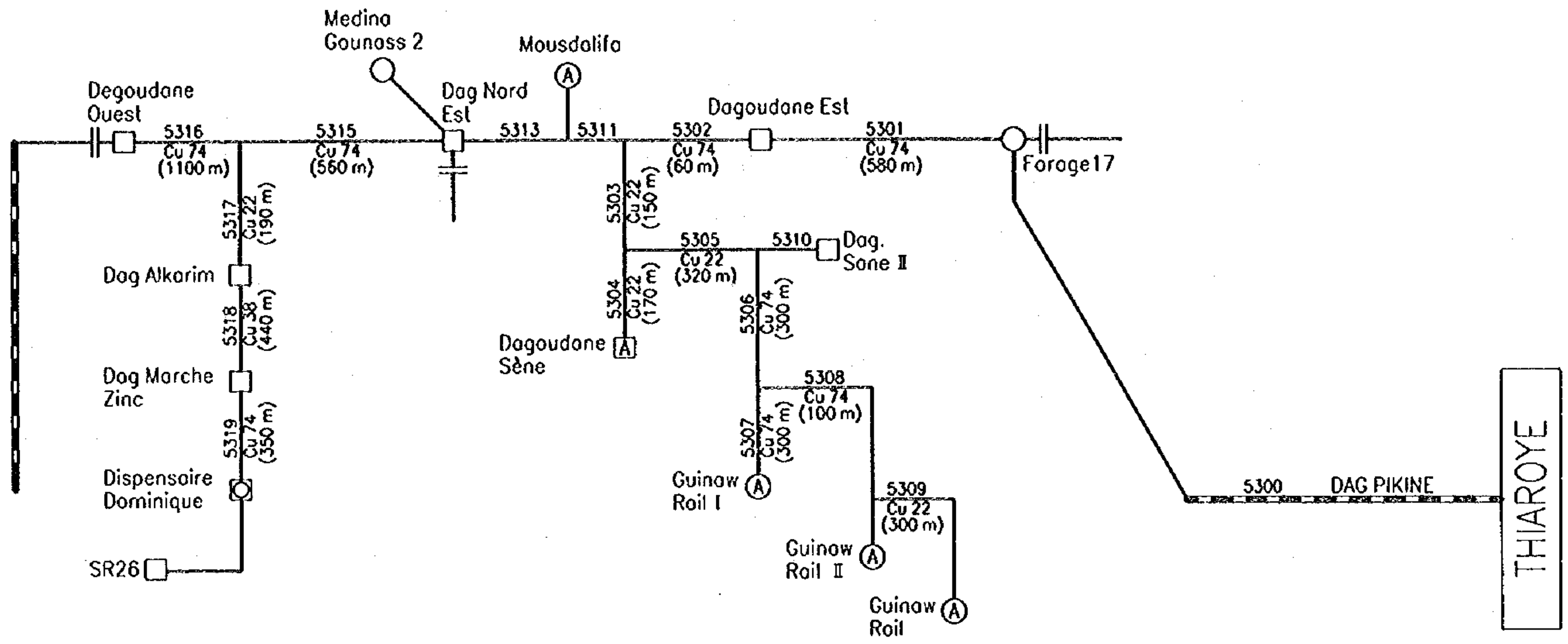
Fig. 7.4.2-3 Existing 6.6kV Lines to be Improved (3/6)

Thiaroye : Labo Pêcherie Feeder

SENELEC | EPDC INTERNATIONAL LTD. TOKYO JAPAN

O.R.: SUBMITTED:
T.R.: RECOMMENDED:
C.K.: APPROVED:
DATE



Legend

○	Private
□	SENELEC
⊡	Common (Mixed)
▥	Sectionalizing Poste
⊣⊢	Normally open condition
▬	Underground Line
—	Overhead Line

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Fig. 7.4.2-3 Existing 6.6kV Lines to be Improved (4/6)

Thiraroye : Dag Pikine Feeder

SENELEC | EPDC INTERNATIONAL LTD. TOKYO JAPAN

D.R.: SUBMITTED:
T.R.: RECOMMENDED:
C.K.: APPROVED:
DATE

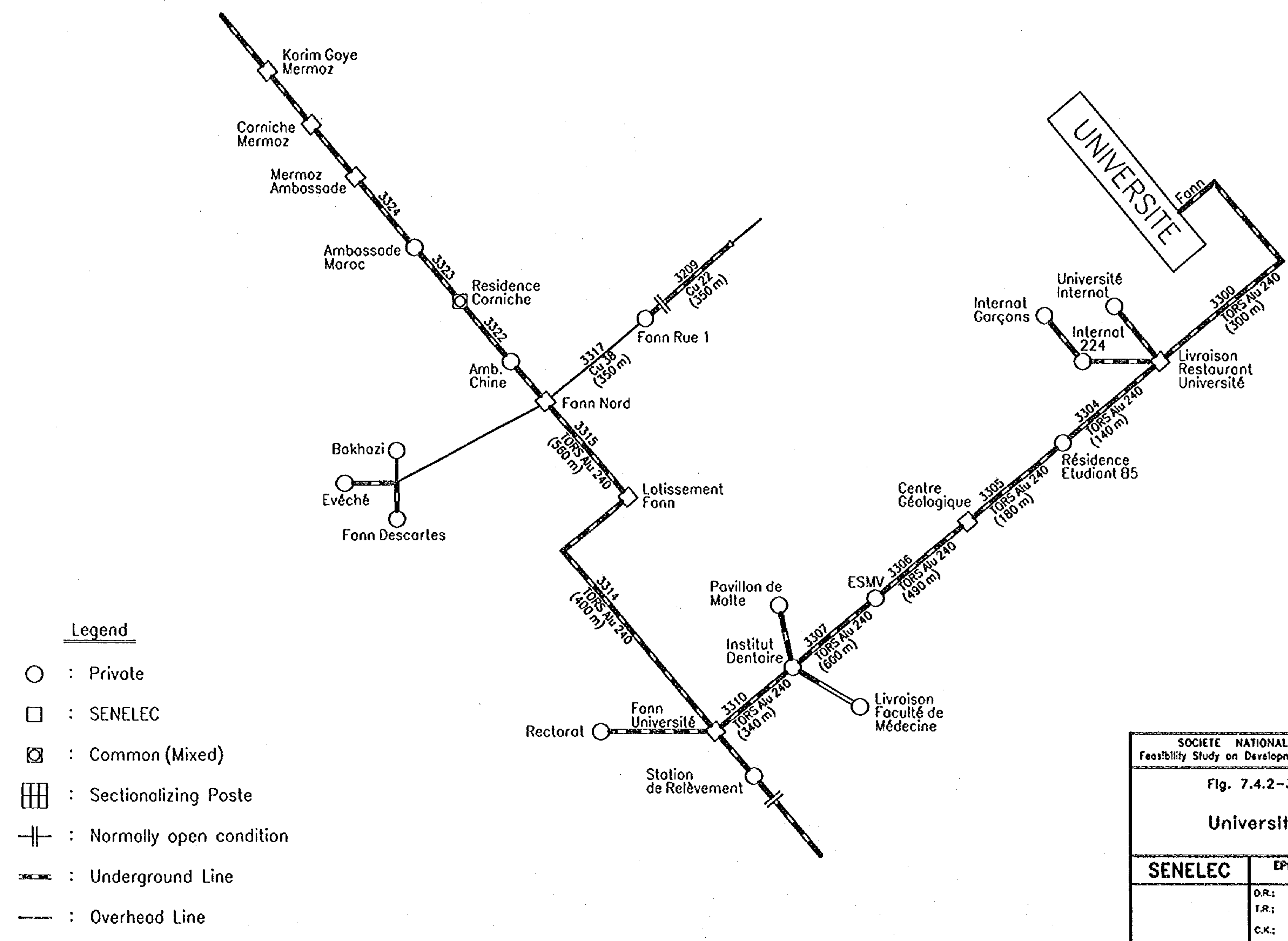

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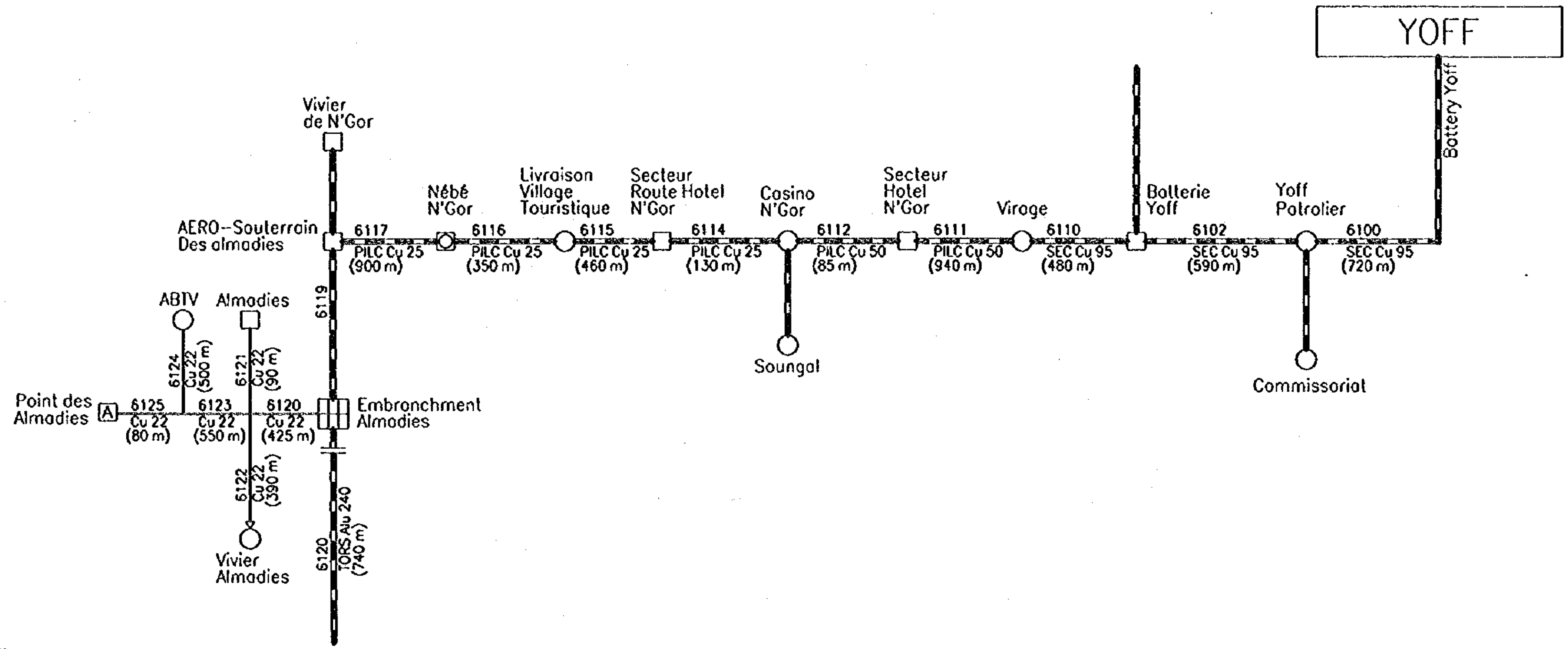
Fig. 7.4.2-3 Existing 6.6kV Lines to be Improved (5/6)

Université : Fann Feeder

SENELEC	EPDC INTERNATIONAL LTD. TOKYO JAPAN
	D.R.: SUBMITTED:
	T.R.: RECOMMENDED:
	C.K.: APPROVED:
	— — — DATE



Legend

- ○ : Private
- □ : SENELEC
- ⊠ : Common (Mixed)
- ▥ : Sectionalizing Poste
- ⊣⊢ : Normally open condition
- ▬ ▬ : Underground Line
- —— : Overhead Line

SOCIETE NATIONALE D' ELECTRICITE DU SENEGAL
Feasibility Study on Development of Electric Power system in Dakar Area

Fig. 7.4.2-3 Existing 6.6kV Lines to be Improved (6/6)

Aéroport Yoff : Battery Yoff Feeder

SENELEC	EPDC INTERNATIONAL LTD. TOKYO JAPAN	
	D.R.:	SUBMITTED:
	T.R.:	RECOMMENDED:
	C.K.:	APPROVED:
	— — —	DATE

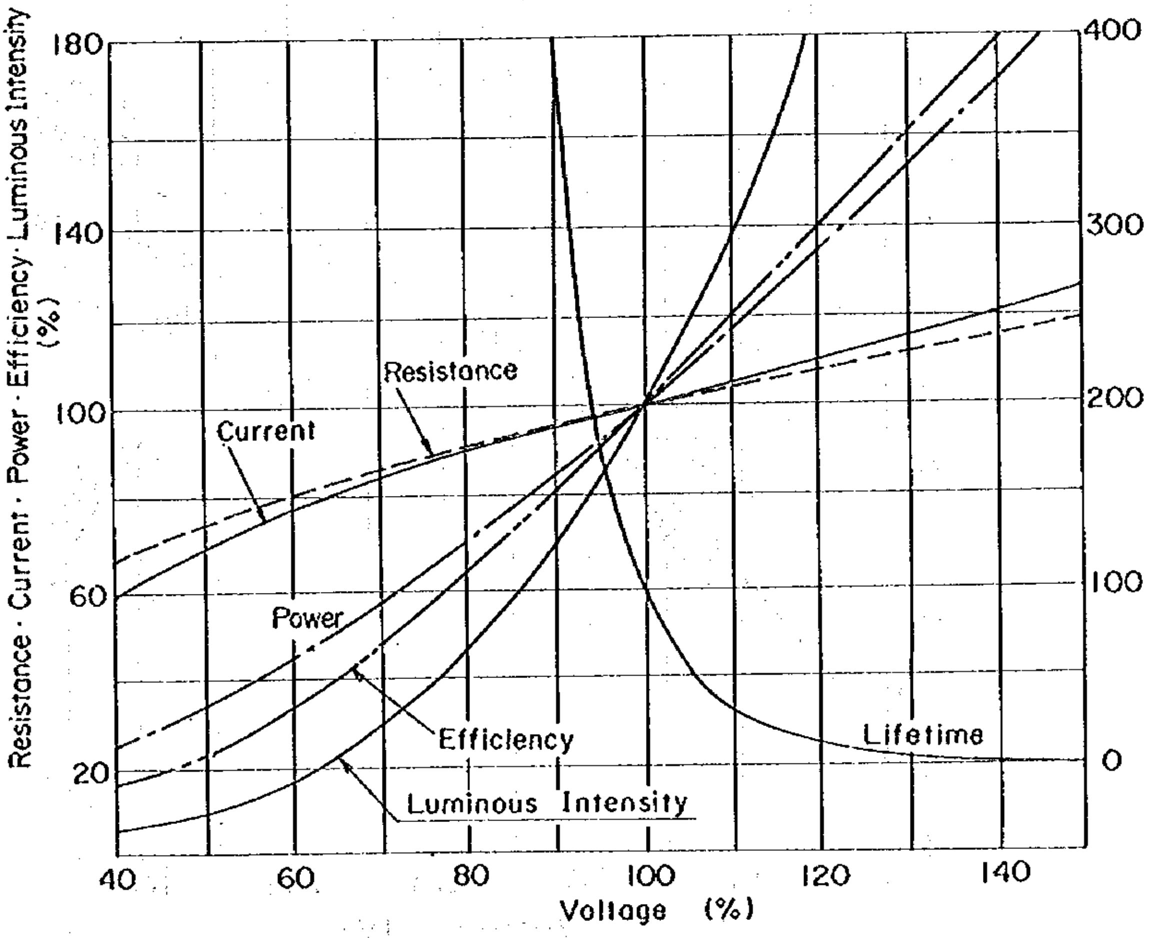


Fig. 7·4·3-1 Voltage Characteristics of Incandescent Lamp

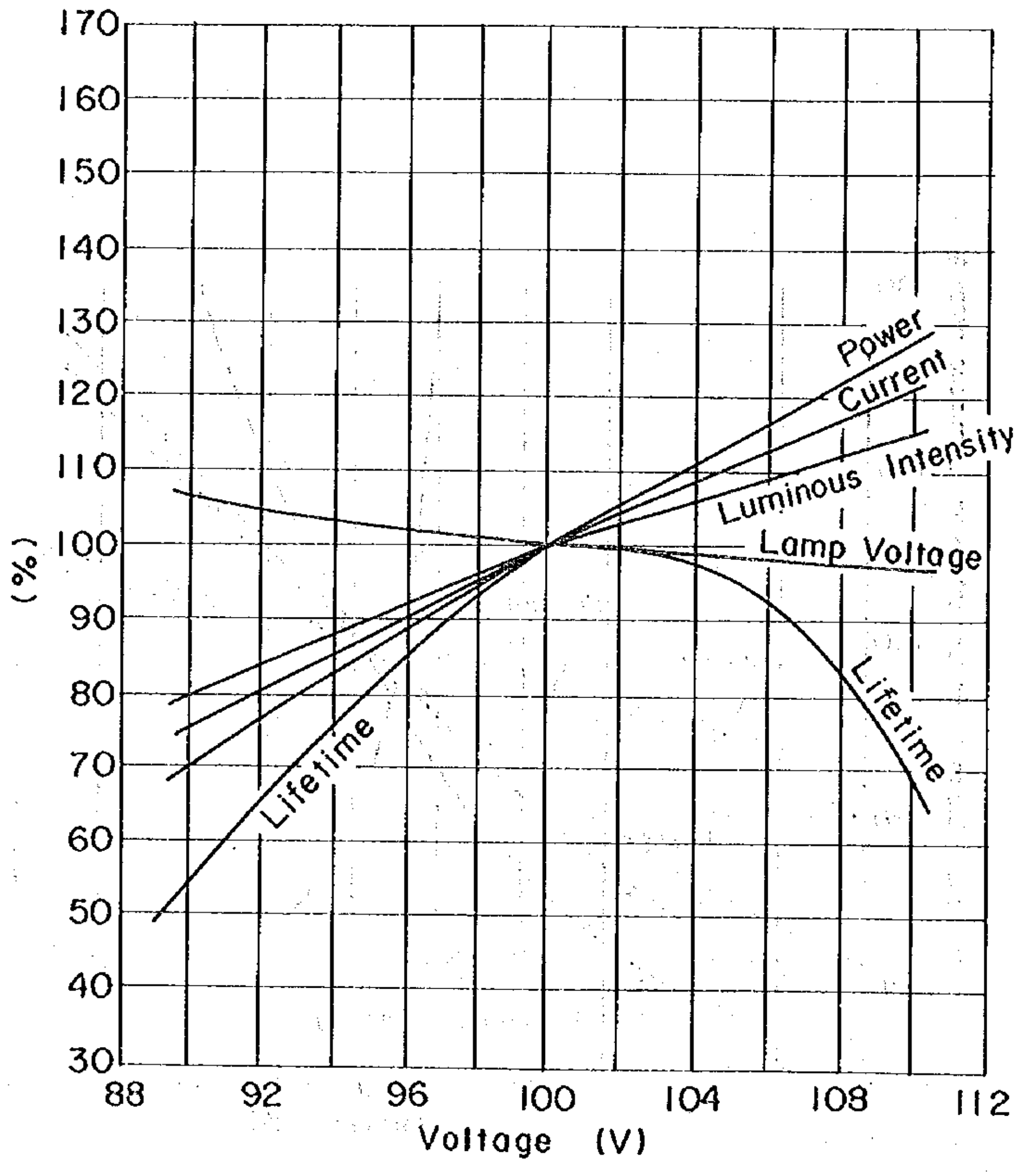


Fig. 7.4.3-2 Voltage Characteristics of Fluorescent Lamp (100V, 20W, Room temperature 26°C)

Fig. 7.4.3-3 Expansion Plan of Low Voltage Distribution Network (1/2)

A. Planned Area for Expansion

① Madien Khary Dieng
② Rt. de Boune
③ Rt. de Marine
④ Rt. de Malika

B. Location of Poste

1 Angle Mouse (30 kV)
2 Boune 1 (6.6 kV)
3 Boune 2 (6.6 kV)
4 Yeumbeul Marine (6.6 kV)
5 Yeumbeul Ben Baraque (6.6 kV)